ROOTS TUBERS & BANANAS

Pre-proposal 2017-2022

August 2015

CGIAR

RESEARCH PROGRAM ON
Roots, Tubers and Bananas

Acknowledgements

This Pre-proposal was prepared by a cross center and interdisciplinary writing team made up of Bhawana Upadhyay (RTB-CIP), Clair Hershey (CIAT), Claudio Proietti (RTB-CIP), Dagmar Wittine (RTB-CIP), Dietmar Stoian (Bioversity), Gordon Prain (CIP), Graham Thiele (RTB-CIP), Inge van den Bergh (Bioversity), James Legg (IITA), Netsayi Mudege (CIP), Oscar Ortiz (CIP), Philippe Monneveux (CIP), Piet van Asten (IITA) and Simone Staiger (CIAT). Gary Harrison provided final editing and Cecilia Lafosse help with graphics. It drew on a huge effort from many more CGIAR scientists and collaborators from partner organizations.

The document benefited from constructive discussion and feedback around the program structure and governance mechanisms provided by the Independent Evaluation Arrangement team which evaluated RTB in 2015. Commentary on the first draft from the CIP Board of Trustees, the Independent Steering Committee, and the CGIAR Consortium Board and Office greatly helped in improving content. Finally, we thank the external reviewers of the business cases at flagship project and cluster level which was a vital input into the writing process.

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ABBREVIATIONS

A4NH	CGIAR Research Program on Agriculture for Nutrition and Health (Global Integrating CRP)
AFS	Agri-Food System
AGUAPAN	Asociación de Guardianes de Papa Nativa, Peru
ALINe	Agricultural Learning and Impact Network
ARI	Agricultural Research Institute
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
AVRDC	The World Vegetable Center
BA	Banana
BAPNET	Banana Asia Pacific Network
BARNESA	Banana Research Network for Eastern and /southern Africa
BBTD/BBTV	Banana bunchy top disease / Banana bunchy top virus
BecA	Bioscience Eastern and Central Africa
BGI	Beijing Genomics Institute, China
BINGO	Big international Non-Governmental Organization
Bioversity	Bioversity International
BMGF	Bill and Melinda Gates Foundation
BMZ	Bundesministerium fuer Wirtschaftliche Zusammenarbeit und Entwicklung, Germany
BTI	Boyce Thompson Institute for Plant Research at Cornell University
BXW	Banana *Xanthomonas* Wilt
CA	Cassava
CABI	Commonwealth Agricultural Bureau International, UK
CapDev	Capacity Development
CARBAP	Centre Africain de Recherches sur Bananiers et Plantains, Cameroun
CAS	Chinese Academy of Science
CATAS	Chinese Academy of Tropical Agricultural Sciences
CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CBSD	Cassava Brown Streak Disease
CC	Crosscutting
CCAFS	CGIAR Research Program on Climate Change, Agriculture and Food Security (Global Integrating CRP)
CCARDESA	Centre for Coordination of Agricultural Research and Development for Southern Africa
GCARD	Global Conference on Agricultural Research for Development
CGIAR	Organization dedicated to international agricultural research
CIALCA	Consortium for Improving Agriculture Based Livelihood Systems in Central Africa
CIAT	International Center for Tropical Agriculture

CIP	International Potato Center
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
Cluster	Cluster of Activity
CMD	Cassava Mosaic Disease
CNRA	Centre National de Recherche Agronomique, Cote d'Ivoire
CORAF	West and Central African Council for Agricultural Research and Development (CORAF/WECARD)
CORPOICA	Corporación Colombiana de Investigación Agropecuaria
CRI	Crops Research Institute, Ghana
CRISPR	Clustered, regularly interspaced, short palindromic repeat ; genome editing tool
CRP	CGIAR Research Program
CRS	Catholic Relief Service
CSTRU	Cassava and Starch Technology Research Unit, Kasetsart University Thailand
CTCRI	Central Tuber Crops Research Institute, India
CWB	Cassava Witches Broom
CWR	Crop Wild Relative
DAFF	Department of Agriculture, Forestry and Fisheries, Australia
DARS	Department of Agricultural Research Services, Malawi
DCLAS	CGIAR Research Program on Dryland Cereals and Legumes AgriFood systems (AFS-CRP)
DFID	Department for International Development, United Kingdom
DGD Belgium	Directorate General for Development Cooperation, Belgium
DI	Discovery
DNA	Deoxyribonucleic acid
DoA(E)	Department of Agriculture (Extension), Thailand
DRC	Democratic Republic of the Congo
DRD	Department for Research and Development, Tanzania
EARI	Ethiopian Agricultural Research Institute
EMBRAPA	Brazilian Agricultural Research Corporation
EPPO	European and Mediterranean Plant Protection Organization
ETH	Eidgenoessische Technische Hochschule, Switzerland
FAO	Food and Agriculture Organization of the United Nations
FARA	Forum for Agricultural Research in Africa
FAVRI	Fruits and Vegetables Research Institute, Vietnam
FERA	Fera Science Ltd.
FOC TR4	*Fusarium oxysproum f.sp. cubense* – Tropical Race 4 (a.k.a. Panama Disease)
FONTAGRO	Fondo Regional de Tecnologia Agropecuaria

FoodSTART	Root and Tuber Crops Research & Development Programme for Food Security in the Asia and the Pacific Region
FP	Flagship Project
FTA	CGIAR Research Program on Forests, Trees and Agroforestry (AFS-CRP)
GENNOVATE	Enabling gender equality in agricultural and environmental innovation
GIS	Geographic Information System
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GMO	Genetically Modified Organism
HH	Household
Humidtropics	CGIAR Research Program on Integrated Systems for the Humid Tropics
IAPSC	Inter-African Phytosanitary Council
ICM	Integrated Crop Management
ICRAF	World Agroforestry Centre
ICT	Information and Communications Technology
IDH	The Sustainable Trade Initiative
IDIAF	Instituto Dominicano de Investigaciones Agropecuarias y Forestales, Republica Dominicana
IDO	Intermediate Development Outcome
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute
IIAM	Agricultural Research Institute of Mozambique
IICA	Inter-American Institute for Cooperation on Agriculture
IITA	International Institute of Tropical Agriculture
ILAC	Institutional Learning and Change Initiative
ILRI	International Livestock Research Institute
INERA	Institut National pour l'Etude et la Recherche Agronomiques, DR Congo
INIA	Instituto Nacional de Innovación Agraria, Peru
INIAP	Instituto Nacional de Investigaciones Agropecuarias, Ecuador
INISAV	Instituto de Investigaciones de Sanidad Vegetal, Cuba
INRA	Institut National pour l'Etude et la Recherche Agronomiques
IPB	Institut Pertanian Bogor (Bogor Agricultural University) Indonesia
IPM	Integrated Pest Management
IPPC	International Plant Protection Convention
IRAF	Institut de Recherches Agronomiques et Forestières, Gabon
IRD	Institut de Recherche pour le Développement
ISABU	Institut des Sciences Agronomiques du Burundi
ITC	International (Musa Germplasm) Transit Center

KALRO	Kenya Agricultural and Livestock Research Organization
KSU	Kansas State University
KU Leuven	Katholieke Universiteit Leuven, Belgium
LAC	Latin America and the Caribbean
LAMP	Loop Mediated Amplification
Livestock	CGIAR Research Program on Livestock (AFS-CRP)
M&EL	Monitoring and evaluation and Learning
MAIZE	CGIAR Research Program on Maize
MAS	Molecular-assisted selection
MSU	Michigan State University
MUSALAC	Red Latinoamericana y del Caribe para la Investigación y el Desarrollo de las Musaceas
MusaNet	Global collaborative framework for Musa genetic resources
NaCRRI	National Agricultural Crops Resources Research Institute, Uganda
NAR(E)S	National Agricultural Research (and Extension) Systems
NARITA	High-yielding and disease-resistant banana hybrids
NARO	National Agricultural Research Organisation, Uganda
NRCB	National Research Centre for Banana, India
NRCRI	National Root Crops Research Institute, Nigeria
NRI	Natural Resources Institute, UK
NSTDA - BIOTEC	National Center for Genetic Engineering and Biotechnology, Thailand
OFSP	Orange-fleshed sweetpotato
PATH	Health-related not for profit organization
PB	Place Based
PIM	CGIAR Research Program on Policies, Institutions and Markets (Global Integrating CRP)
PO	Potato
PROINPA	Fundación PROINPA, Bolivia
ProMusa	Knowledge-sharing Platform on Bananas
PVS	Participatory Varietal Selection
R&D	Research and development
RAFS	CGIAR Research Program on Rice Agri-food System
R4D	Research for development
RAB	Rwanda Agricultural Board
RBM	Results Based Management
RHUL	Royal Holloway University of London
RNAi	RNA interference

RTB	CGIAR Research Program on Roots, Tubers and Bananas
SADC	South African Development Community
SARI	Savanna Agricultural Research Institute, Ghana
SDC	Swiss Development Cooperation
SDG	Sustainable Development Goal
SID	Sustainable Intensification and Diversification
SLO	System-level Outcome
SME	Small and Medium Enterprises
SRF	CGIAR Strategy and Results Framework
SSA	Sub-Saharan Africa
SU	Syracuse University, USA
SUN	Scaling Up Nutrition (movement)
SW	Sweetpotato
ToC	Theory of Change
UAK	Université d'Agriculture de Kétou, Benin
UCLA	University of California, Los Angeles
UDSM	University of Dar es Salaam, Tanzania
UM	University of Miami, USA
UNAN	National Autonomous University of Nicaragua
UNEP	United Nations Environment Programme
UNIKIN	University of Kinshasa, DR Congo
UNIKIS	University of Kisangani, DR Congo
UPLB	University of the Philippines Los Baños
UQ	University of Queensland, Australia
USAID	United States Agency for International Development
VAAS	Vietnam Academy of Agriculture Sciences
W1/2/3	CGIAR funding windows
WHEAT	CGIAR Research Program on Wheat (AFS-CRP)
WLE	CGIAR Research Program on Water, Land and Ecosystem (Global Integrating CRP)
WUR	Wageningen University and Research Centre
YA	Yam
ZARI	Zambia Agriculture Research Institute

PART 1: SUMMARY NARRATIVE

1 OVERVIEW

The CGIAR Research Program on Roots, Tubers and Bananas (RTB) is one of eight Agri-Food System CRPs (AFS-CRP). It will incorporate livelihood systems work, especially from the CRP Integrated Systems for the Humid Tropics (Humidtropics) with which strong collaboration has been established, and expand collaboration with Global Integrated CRPs and the other AFS-CRPs. RTB brings together four CGIAR centers (Bioversity, CIAT, CIP, and IITA) and CIRAD (representing the French organizations IRD, INRA, and Vitropic) with more than 200 partners for research on banana, cassava, potato, sweetpotato, yam, and minor roots and tubers. Termed "vegetatively propagated staple crops," they are linked by common breeding, seed, and postharvest issues, and by the frequency with which women are involved in their production and use. Depending on the ecology, RTB crops often complement maize, rice, wheat, legumes, vegetables, and livestock, while also forming part of many agro-forestry systems.

1.1 Alignment with the CGIAR Strategy and Results Framework (SRF)

Around 300 million poor people[1] in developing countries depend on RTB value chains for food security and income; many more benefit through their consumption. RTB addresses societal grand challenges of the 21st century, aligned with the Sustainable Development Goals (SDG). The pre-proposal will advance the three system-level outcomes (SLOs) proposed in the CGIAR SRF, contributing significantly to intermediate development outcome (IDO) targets (Table 1). The 26 primary target countries where RTB crops are of greatest importance include 17 of the 20 prioritized for CGIAR (2015) site integration (+) and all 6 of those fast-tracked for more intensive integration (CGIAR 2015).

Table 1. Beneficiaries for target IDOs by SLO

SLO	Target IDOs	Total number of beneficiaries (2022)[1]	Primary target countries
1	Increased incomes and employment	20,000,000 people (50% women) have increased their income 30,000 small and medium enterprises are operating more profitably in the RTB seed and processing sectors	**Africa**: Burundi, Cameroon[+], Congo, Democratic Republic of the Congo (DRC)[+], Ethiopia[++], Ghana[+], Ivory Coast, Kenya[+], Malawi[+], Mozambique[+], Nigeria[++], Rwanda[+], Tanzania[++], Uganda[+], Zambia[+] **Americas**: Bolivia, Colombia, Ecuador, Haiti, Peru **Asia**: Bangladesh[++], China, India[+], Indonesia, Nepal[+], Thailand, The Philippines, Vietnam[++]
1, 2	Increased productivity	8,000,000 farm households have increased RTB yield through adoption of improved varieties and sustainable management practices	
2	Improved diets for poor and vulnerable people	10,000,000 people (50% women) have improved their diet quality (measured by dietary diversity score)	
3	Enhanced benefits from ecosystem goods and services	800,000 ha of farm land with soil carbon and nutrients content improved	
3	More sustainably managed agro-ecosystem	1,700,000 ha of current RTB production area converted to sustainable cropping systems	

[1]Figures on beneficiaries are aggregated for all RTB crops. Specific ranges for change (e.g., income and yield increase) are presented by cluster/crop in Part 2 (Flagship level).

[1] Defined as earning less than US$ 1.25 at purchasing power parity (World Bank 2015).

SLO 1: Reduced poverty

Innovations in RTB crops have tremendous impact on poverty reduction by (1) increasing farmers' income through linkages to markets and adding value, (2) enhancing non-agricultural rural employment especially through processing (often predominantly a woman's activity), (3) creating opportunities for youth employment, and (4) lowering food costs to consumers. But unless gender roles and needs are considered, innovation can worsen gender inequity (Sarapura 2012). Increasing opportunities for women can have a powerful impact on productivity and agriculture-led development and reduce gender disparities in access to inputs, assets, opportunities, information, and other resources (Margolies & Buckingham 2013; FAO 2014).

RTB crops have doubled in area in developing countries since 1960, and expanded even more in Africa. The picture is mixed, however, for yield increase (Table 2). Little change for some crops and regions but where market conditions are favorable and appropriate new technology is available, yield gains have been considerable—for example, in the context of industrial markets for cassava in South-east Asia (Robinson & Srinivasan 2013). Recent adoption studies in Sub-Saharan Africa (SSA) are grounds for optimism for further yield gains: adoption of modern varieties—many developed or disseminated by CGIAR—of cassava, potato, yam, sweetpotato, and banana was, respectively, 39.7%, 34.4%, 30.2%, 6.9%, and 6.2% (ISPC, SPIA 2014).

Table 2. Change in production, area, and yield for RTB crops in developing countries

Crops	Production (million t)			Area (million ha)			Yield (t/ha)		
	1961–63	1986–88	2011–13	1961–63	1986–88	2011–13	1961–63	1986–88	2011–13
Banana	21.1	42.8	105.0	2.0	3.2	5.0	10.5	13.3	21.0
Cassava	74.6	139.0	266.1	9.9	14.3	21.3	7.5	9.8	12.5
Plantain	13.4	23.9	37.5	2.5	4.1	5.4	5.3	5.8	6.9
Potato	28.8	72.0	224.5	3.5	6.1	12.6	8.1	11.9	17.8
Sweetpotato	93.0	123.4	101.2	12.6	9.0	8.0	7.4	13.7	12.6
Yam	8.6	14.0	56.5	1.2	1.8	6.2	7.3	7.6	9.1

Source: FAOstat 2015. FAOstat reports banana and plantain separately; however, no systematic criteria are used to make this separation. Note: Hectare (ha), ton (t).

RTB crops offer high potential yields, but farmers often realize less than half that potential due to the use of poor quality "seed" of limited genetic diversity; biotic and abiotic constraints; and poor management practices. Limited institutional arrangements that support markets, policy, knowledge, and technological development also restrain yield potential. Women's farm yields are typically much lower than men's, reflecting specific gender barriers that depress women's productivity, including access to information and technology (FAO 2014; Mudege et al. 2015). Low productivity in turn limits farmers from taking advantage of market opportunities and the chance to increase income. Hence, breeding for higher nutritional and processing quality, user-preferred traits, and adaptation to stressful environments; access to improved quality planting material; better management practices; integrated gender research; and improved institutional arrangements are needed to make use of the full potential of RTB crops to exit poverty.

SLO 2: Improved food security and nutrition for health

With an average production of around 790 million tons on 59 million ha in 2011–2013 (FAOstat 2015), RTB crops represent the second most important set of crops in developing countries after cereals. The energy output per ha/day of RTB crops is considerably higher than that of grains, providing one of the cheapest sources of dietary energy. In 2011, RTB crops provided around 15% of the daily per capita calorie intake for the 763 million people living in least developed countries. In some countries, this figure can be as high as 48%—for instance, in Ghana, where they provide more than 1450 calories per capita/day (ibid.).

In SSA and Asia, vitamin A deficiency is widespread, contributing to increased risks of blindness, illness, and premature death, particularly in small children and pregnant/postpartum women. Iron and zinc deficiencies are also common. Orange-fleshed sweetpotato (OFSP) is a proven biofortified crop: 50 g/day can meet the vitamin A requirements of a young child, and 1.1 million households have adopted OFSP across several African countries. Yellow cassava, also rich in vitamin A, is going to scale in Nigeria. Banana cultivars can be significant sources of vitamin A (Davey et al. 2009), and potato breeding has achieved nutritionally significant levels of Fe and Zn (Thiele et al. 2010).

RTB crops are mostly produced, processed, and traded locally, making them less vulnerable to abrupt price rises in international markets. They complement cereals, helping to build stronger, more diversified agri-food and farming systems to reduce the risk of food shortages and nutritional shortfalls. Their potential is often limited, however, by the lack of preferred nutritious varieties, the stability of micronutrients in fresh and processed food, as well as favorable value chains and institutional innovation arrangements.

SLO 3: Improved natural resources systems and ecosystem management

The impact of RTB crops on the natural resource base and the larger environment varies widely depending on the crop and the cropping system. As human populations grow and extend their environmental impacts, the different systems will need to be evaluated for their potential to intensify production and increase productivity. Approaches need to be devised that enable rural women and men smallholders to meet their food and income needs while at the same time safeguarding the long-term health (productivity) of farming and natural environments. Conservation and on-farm use of crop genetic diversity can contribute to resilient cropping systems and increase the capacity to respond to evolving stresses. Some RTB crops tolerate stresses such as drought and heat and should be relatively robust in the face of climate change; others may require major supplemental efforts to maintain production. A strong focus on conserving and rehabilitating the soil resource base will be essential to ensure total systems' sustainability in the face of increasing shocks from climate change.

1.2 Added value of being a program

The choice of flagships and their "clusters of activity" (clusters) that make up the program build on the RTB-led assessment of research priorities for each of the crops (see section 2). This adds value to the program structure by promoting cohesion across flagships, and includes **four types of interlinked flagship projects** (FPs) and their associated clusters (see part 2, and Annex 5 for an overview of all FPs and their clusters).

Discovery FP1 includes a set of five clusters that provides well-targeted, high-potential upstream research and next generation breeding to accelerate genetic gain in yield, adaptation, resilience, and quality traits across all crops in a client-responsive way. FP1 generates products for delivery FPs once proof of concept is established, including markers, approaches to genomic selection, and game-changing traits (where these present recalcitrant challenges to breeding). The Discovery flagship also adds value to genebanks by creating linkages between gene discovery and breeding, and monitoring in-situ diversity to ensure resilient cropping systems and capacity to respond to climate change and other stresses. The RTB breeding platform tracks variety and trait pipelines; monitors genetic gain; supports shared services, tools, and information; and serves as a community of practice for breeders, geneticists, and molecular biologists.

Delivery FPs (FP2–FP4) consist of a varying number of crosscutting and crop-specific clusters that focus on research products that generate significant outcomes and impact over the next six years. Each delivery cluster focuses on a **lead** product that can achieve disruptive innovation (Christensen 2012). For example, OFSP was a disruptive innovation for SSA farmers who initially preferred a white-fleshed type. OFSP has been aggressively promoted by building awareness of its healthiness, especially among women as primary caregivers, to generate strong demand pull and is now moving to aggressive scaling. Each Delivery cluster includes **linked** research products from different disciplines to enable uptake of the **lead** product, recognizing that varieties require functional seed systems and evidence of efficacy can influence policy change.

Integrated livelihood systems FP5 is a special type of FP among the Delivery FPs which consists of crosscutting and place-based (PB) clusters that are designed to enhance individual and institutional capacities to innovate and support women and youth employment. It brings together key technologies from delivery that contribute to livelihoods. It incorporates elements from broader production systems in an institutional context, creating a strong feedback loop to the other flagships to ensure that technology is relevant for clients. It will develop tools, methods, and approaches that improve identification and prioritization of problems and opportunities. And FP5 will encourage investment and develop, test, and experiment with RTB tools/methods/technologies within the larger systems context for sustainable intensification and improved livelihoods.

Impact at scale FP6 includes outcome support services and feedback loops to create the capacities, research and development (R&D) partnerships, and innovation environments for product delivery to take research products and outcomes to scale. Hence FP6 addresses strategic research to enhance gender equity and to create a more favorable context for integrated gender research in the other flagships. Strategic gender research will be implemented to understand key constraints and opportunities affecting the differential participation of women and men in RTB value chains and technology innovation, and to seek ways for making participation more equitable and effective, leading to larger-scale development outcomes. Foresight, as well as ex-ante and ex-post studies, will instill an impact culture to better align RTB research with outcomes and ensure value for money.

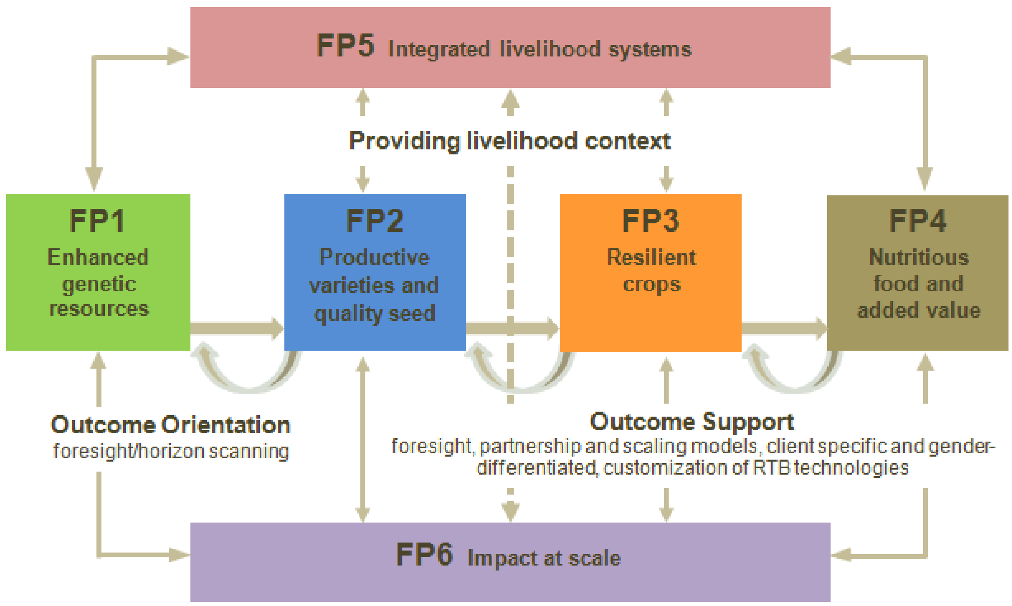
All FPs contain **one or more crosscutting clusters** under which research is conducted to develop new tools and methods jointly with other clusters. They provide methodological support to and spaces for shared learning with other clusters, both inside the same FP and across other FPs.

Flagship and cluster business cases were subjected to an intensive external review process in May/June 2015. Detailed feedback informed the feasibility of each cluster and their integration into FPs. And although reviewers found business cases generally solid, they drew attention to gaps and inconsistencies that led to ongoing reformulation of the FP descriptions and their incorporation into this pre-proposal.

1.3 Strategy for ensuring that international public goods are delivered: theory of change and impact pathways

The theory of change (ToC) of the RTB program level is based on a balanced portfolio with a multidisciplinary, integrated research agenda (see section 1.2 and Fig. 1). FP1 contributes breeding tools such as markers and new traits that can be incorporated into the FP2 clusters as its primary next users. FP2 includes not only all of the upstream part of the breeding for each of the crops, but also complementary seed and other technology and approaches for demand creation. Each of the FP2 clusters has its own scaling strategy, but FP2 also links with FP3 and FP4 as next users of prototype varieties that require further participatory selection to match end user's needs and particular constraints (e.g., disease resistance). FP3 develops an array of products for pest and disease characterization and management in diverse crops and improved agronomy for more resilient cropping systems. FP4 also uses prototype varieties with high micronutrients or desired postharvest and processing traits. As well, it develops a complementary set of research products and translates them into nutrition outcomes, improved efficiency, and reductions in postharvest loss. FP5 functions as an "innovation broker" to draw in and integrate technologies and other products from FP2–FP4 into a livelihood context and to provide feedback to the other flagships for demand pull from a user livelihood perspective. FP6 provides a guiding framework for the whole set of flagships to steer them toward the areas of greatest return, build their capacity for better partnering and capacity development, and ensure improved gender relevance. The set of interlinked and interactive flagships described, allows AFS-CRP RTB to reach CGIAR goals (SLOs), measured through (Sub)-IDOs (Fig. 1).

For clusters in FP2–FP5, research products were identified, impact pathways tentatively mapped out, scaling strategies agreed, and indicators for (Sub)-IDOs constructed to provide the basis for results-based management (RBM). The clusters in FP6, as well as crosscutting clusters in other FPs, do not directly contribute to (Sub)-IDOs, but rather via the other clusters that they link with. For crosscutting clusters, progress metrics are used, such as indicators measuring the uptake and use of methods and tools for FP6. For more details, see Part 2 of the pre-proposal (FP descriptions).



IDOs	Sub IDOs	Flagship projects contribution					
		1	2	3	4	5	6
Increased incomes and employment	Diversified enterprise opportunities		x		x	x	
	More efficient use of inputs				x		
Increased productivity	Reduced pre- and -post production losses, including those caused by climate change			x	x		
	Closed yield gaps through improved agronomic and animal husbandry practices		x	x		x	
	Enhanced genetic gain	x	x				
	Increased conservation and use of genetic resources	x	x				
Improved diets for poor and vulnerable people	Increased availability of diverse nutrient-rich foods		x				
	Optimized consumption of diverse nutrient-rich foods				x	x	
Enhanced benefits from ecosystem goods and services	Agricultural systems diversified and intensified in ways that protect soils and water					x	
	Enrichment of plant and animal biodiversity for multiple goods and services	x					
More sustainably managed agro-ecosystem	Increased resilience of agro-ecosystems and communities, especially those including smallholders			x			
Mitigation and adaptation achieved	Enhanced capacity to deal with climatic risks and extremes	x	x	x		x	
Equity and inclusion achieved	Gender-equitable control of productive assets and resources		x	x	x	x	x
	Improved capacity of women and young people to participate in decision-making					x	x
Enabling environment improved	Increased capacity of beneficiaries to adopt research outputs						x
	Conducive agricultural policy environment		x	x	x		
National partners and beneficiaries enabled	Enhanced institutional capacity of partner research organizations	x					x
	Enhanced individual capacity in partner research organizations through training and exchange	x	x				x
	Increased capacity for innovation in partner development organizations and in poor and vulnerable communities			x	x	x	x

Figure 1. RTB program structure and contribution to (Sub)-IDOs

RTB will strengthen implementation of RBM, piloted in Phase I by RTB and Humidtropics. The RBM system will include strong monitoring, evaluation, and learning (M&EL) as a management tool to provide business intelligence for decision-making and to track progress and demonstrate impact. The system will revolve around five RBM principles: (1) a clear and logical program design that ties resources and activities to expected results; (2) description of roles and responsibilities for RTB scientists/management as well as for partners involved in implementation; (3) sound judgments on how to improve performance on an ongoing basis; (4) demonstrated accountability and benefits to stakeholders; and (5) reliable and timely information made available to CGIAR and key stakeholders. RBM will improve program performance with better accountability, transparency, relevance, decision-making, and learning that delivers results, contributes to outcomes and impact, and delivers value for money.

RTB's RBM framework is flexible and iterative, resting on the different nested ToC and impact pathways at program, FP, and cluster levels. It incorporates experiential insights and lessons to improve its utility.

Central to RBM is developing strong alliances with stakeholders, especially of the development partners who share responsibility for achieving outcomes at scale. RBM workshops will convene the stakeholders potentially involved with a selected RTB cluster at focus country and sub-regional levels. They will be jointly planned with other CRPs and include stakeholders with experience in gender integration and mobilizing women and other social groups. During the workshops, stakeholders and partners validate, contextualize, and improve the delivery cluster impact pathways for the focus country and agree on the framework for joint activities for the Discovery and Impact at scale FPs. This type of work has already begun and has proved highly valuable during the RBM pilot with four selected clusters (see section 5).

2 EVIDENCE OF DEMAND

In Section 1 much evidence of demand was provided directly, aligned with grand societal challenges. Information was also provided about the importance of RTB crops for smallholders' livelihoods and for meeting food security needs for energy and micronutrients.

During consultations with 255 stakeholders in 2010 for the design of RTB Phase I, respondents expressed support for a system-based program on RTB crops. Many suggested a stronger production- or livelihood-systems approach, including participatory action research (Woolley et al. 2011). This was addressed in RTB by co-locating with the systems CRPs, especially Humidtropics, to achieve a livelihood focus. By transitioning to an agri-food system, RTB enhances this approach.

In 2012 RTB conducted a comprehensive, online expert consultation in coordination with ASARECA, CORAF, and CCARDESA in Africa; IICA in Latin America; and multiple partners in Asia. The goal was to identify the highest priorities for research on each of the RTB crops, with more than 1,680 responses.

Table 3. Selected results of ex-ante assessment of selected technologies—lower adoption scenario

Technology	Area '000 ha	NPV (m USD)	IRR	'000,000 HH	'000,000 persons	Poverty reduction '000,000 persons
Banana Bunchy Top Virus	413	1,198	56%	2.1	10.0	0.72
Cassava high-yielding varieties w/CMD & CBSD resistance	2,610	1,201	69%	4.2	21.0	1.00
Potato late blight resistance	774	1,803	62%	2.1	9.5	0.31
OFSP inc. health benefits	673	1,070	51%	3.0	14.7	0.45
Yam clean planting materials and agronomic practices	660	589	40%	2.4	17.9	0.19

Note: *NPV = net present value (10%), IRR = internal rate of return. Project investment period 6 years; benefits, 25 years.*

Participatory stakeholder workshops were held to delve deeper. Building on this, an ex-ante analysis of preferred options (corresponding to technologies in a flagship cluster) was carried out for all crops to estimate probable adoption and rates of return (Table 3). For the five options shown here the IRR ranged from 34-69%. Findings from the consultation and ex-ante analysis are being published and shared widely (https://goo.gl/qt7ZFy). Results guided the selection of prioritized clusters and their products and provide a systematic basis for estimating investment and numbers of beneficiaries.

3 COMPARATIVE ADVANTAGE

Under RTB, CGIAR and French organizations that had been dispersed across individual centers were brought together to exploit several comparative advantages: (1) scientific capacity in human resources and research infrastructure; (2) individual centers' capacity to act as conveners and facilitators across national boundaries, and as an "honest broker" to assemble a broad range of public, private, and development organizations together; and (3) stewardship and access to well-characterized global germplasm collections of major RTB crops.

Combined, RTB comprises a wide range of multidisciplinary expertise that is available to partners working toward common goals. Phase I built on this comparative advantage by establishing a common umbrella to expand partnerships and capacity for crosscutting synergistic work relating to (1) their status as crops of the poor and the implications for poverty reduction and nutrition; (2) predominant roles of women in value chains; (3) vegetative propagation as related broadly to seed systems and to breeding systems; and (4) commonalities in postharvest management, including transportation, storage, and processing.

RTB has a pivotal role in integrative research generating international public goods, which would otherwise not be delivered by National Agricultural Research and Extension Systems (NARES), nongovernmental organizations (NGOs), universities, or private sector. Cassava, banana, sweetpotato, and yam are largely crops of developing countries with limited research investment in the developed world. Potato has a long history of first-world research, but technologies in developing countries lag far behind.

During Phase I RTB vastly increased and began to consolidate existing knowledge of gender relevance and created a network of gender focal points in participating centers. An integrative gender research strategy was developed to ensure that key gender equity issues and opportunities for women and youth are addressed in Phase II (RTB 2013).

4 STRATEGIC FIT AND RELEVANCE OF PARTNERSHIPS

To leverage best practices across CRPs, stimulate interdisciplinary research, and leverage greater contribution to SRF targets, RTB will link with all Global Integrating CRPs: Policies, Institutions and Markets (PIM) for complementary approaches to value chain analysis and development; Agriculture for Nutrition and Health (A4NH), with shared evidence base and advocacy for adoption of biofortified varieties; CCAFS models and metrics for climate-sensitive breeding; and Water, Land and Ecosystem (WLE) for wastewater utilization linked to cassava processing. FP5 (Integrated systems for improved livelihoods) and the other AFS-CRPs (i.e., RAFS, WHEAT, MAIZE, and Livestock) opens a new space for collaboration where RTB crops can be rotations, intercropped, or used as sources of feed. Annex 6 gives details of collaboration between RTB and other CRPs.

The RTB partnership strategy is based upon an analysis of research needs and roles of partners along the impact pathway, closely linked with the capacity development (CapDev) strategy. Many advanced research institutes are involved; some contributed directly to the preparation of the FPs and their associated clusters (e.g., Cornell University in FP1, WUR in FP2 and FP5, Fera in FP3, and NRI in FP4). RTB will build upon existing partnerships for multi-crop research to leverage synergies, including strategic partnerships with the Royal Holloway University of London (RHUL) for metabolomics profiling, with Boyce Thompson Institute for Plant

Research (BTI), at Cornell University, for shared databases and bioinformatics platforms to support next-generation breeding of RTB crops (http://bit.ly/1CKLbV4); and with IRD for a consortium for managing bacterial diseases of RTB crops.

RTB is active in the Comprehensive Africa Agriculture Development Programme and with ASARECA, and is committed to alignment with sub-regional and national plans. RTB is pursuing linkages with the West and Central African Council for Agricultural Research and Development, the Centre for Coordination of Agricultural Research and Development for Southern Africa, and the Forum for Agricultural Research in Africa (FARA) (http://bit.ly/MUJiiH). RTB is particularly interested in sharing of knowledge and experience of gender-responsive R&D and with women farmers' associations and alliances. Currently, under the RTB-University Gender Integration Partnership, RTB is collaborating closely with several universities to help mainstream gender research and prepare a new generation of researchers to cross disciplinary divides.

NARES are partners of choice for much adaptive research, complemented increasingly by novel partnerships to go to scale. RTB will build on the array of networks, partnership arrangements, and innovation platforms already established. This includes partnerships with development organizations for scaling and with local organizations, NGOs, and institutions adept at developing capacity—particularly for producers and other stakeholders along the value chains—and that have the capacity to provide feedback and input into RTB strategies. Collaboration with the private sector will further increase going to scale, leveraging additional resources and entrepreneurial dynamism for accelerated technology promotion.

RTB actively supports research on partnerships. FP6 will promote best practice for partnering, including selecting the right partners and "partnership health check-ups" that build on influential earlier work (Horton et al. 2010). RTB especially supports partnership platforms that bring together multiple partners to learn and scale up. Examples include the International Society for Tropical Root and Tuber Crops; an RTB learning alliance to contain and help farmers recover from banana bunchy top disease (BBTD) in eight African countries; Regional Banana Research for Development (R4D) networks for collective action and knowledge sharing across countries (BARNESA, BAPNET, MUSALAC, and Innovate Plantain) supported by Bioversity and IITA; the Great Lakes Cassava Initiative, led by Catholic Relief Services (CRS) with research support from IITA; the Global Cassava Partnership for the 21st Century, a partnership platform fully supported by CIAT, IITA and RTB; and Sweetpotato for Profit and Health Initiative, a multistakeholder partnership program with CIP, with a goal of reaching 10 million households across 17 SSA countries to significantly reduce malnutrition among children under the age of five.

5 STAKEHOLDER COMMITMENT

As part of RBM, RTB organized stakeholder planning workshops for three delivery clusters: seed potato systems in Kenya, Banana *Xanthomonas Wilt* (BXW) management in Eastern and Central Africa, and cassava processing in Nigeria (http://bit.ly/1C6tb51). A broad range of stakeholders participated: farmers and farmer organizations; national, regional, and international research organizations; ministries and national agencies; private companies; NGOs; and international development agencies. RTB will expand collaboration with stakeholders in the context of GCARD3 and site integration consultation (CGIAR 2015).

During the workshops, stakeholders and RTB scientists co-constructed realistic, nonlinear impact pathways illustrating the interactions between outcome levels and among products and outcomes (http://bit.ly/1FkBU8Z). Priorities were then identified and specific scaling strategies formulated. Stakeholders collaborated to identify enabling and disenabling factors for the causal sequences to play out as expected. Partnership strategies and a framework for action were identified and key elements of a joint M&EL system identified, joint accountability framed and the process of joint learning and scaling laid out. Co-constructing the results framework facilitated the definition of an agreed indicators' framework for monitoring expected changes—based on and aligned with existing national M&E frameworks, data collections, and statistical sources from stakeholders, partners, and the like. In the case of the Discovery cluster "Next Generation Breeding" workshop, stakeholders from private sector companies involved in crop improvement, universities, and NARS developed a set of metrics to measure genetic gain and created strong linkages for joint definition and alignment of breeding targets, reflected in Table FP1.1 (see part 2, FP1). RTB will continue to roll out RBM and organize stakeholder workshops for all clusters. This will make it possible to agree shared responsibilities with stakeholders for achieving SLOs and SDG.

6 LEADERSHIP, MANAGEMENT, AND GOVERNANCE STRUCTURE

RTB operates as an alliance of four CGIAR centers and CIRAD, with CIP as the lead center. Following best practice (IEA 2014) and lessons learned from RTB Phase I, the Independent Steering Committee (ISC) comprises nine members appointed for three years, with possible reappointment for an additional three years. A majority of the ISC are independent members with competencies in gender, partnership, evaluation, and ToC, as well as capacity strengthening and cutting-edge science. The ISC includes the RTB program director (PD) as ex-officio member, the director general (DG) of the lead center as a permanent member, one DG of another participating center (on a rotating two-year appointment), and a high-level representative of CIRAD. Both DGs represent all partner CGIAR centers. The ISC chair is elected from among the independent members. The ISC meets face to face once a year with quarterly video meetings and the chair's interim email updates. It has oversight responsibility for the implementation of RTB and strategic alignment of RTB with the SRF; guides management for results; and approves plans, reports, and budgets. The ISC reports to the lead center board, which has fiduciary responsibility for implementation of RTB.

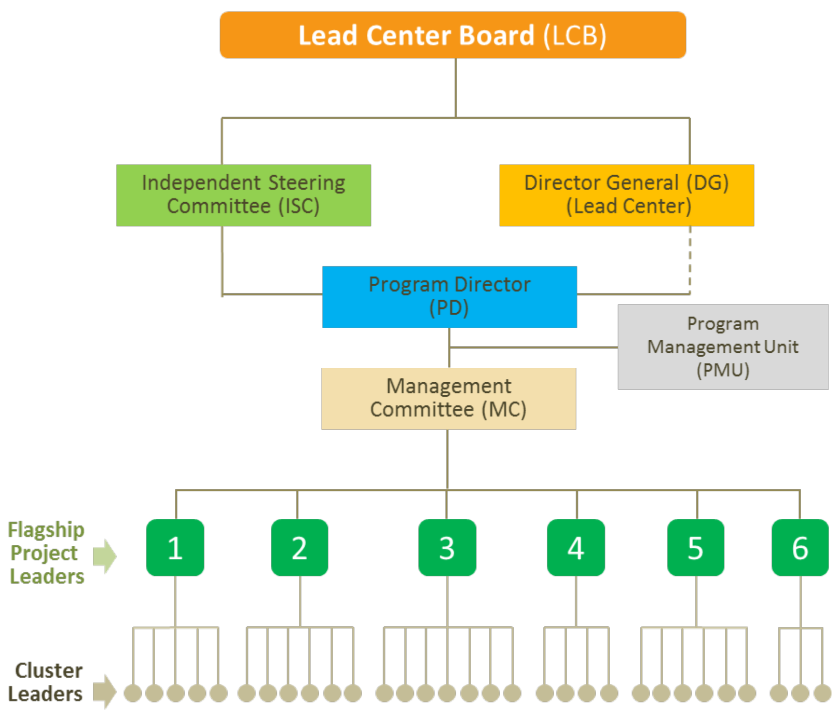


Figure 2. RTB organogram

The Management Committee (MC) consists of the deputy directors general-research for each of the centers and CIRAD on behalf of French partners. The MC, which meets quarterly, leads the management of the CRP and ensures timely implementation of plans, reporting, budgeting, and management for results. The RTB PD chairs the MC and reports to the ISC programmatically and to the DG of lead center administratively (Fig. 2). The PD is supported by a Program Management Unit (PMU).

Flagship project leaders and the RTB gender research coordinator meet monthly to report and plan research. Flagship project leaders provide scientific leadership, ensure science quality in planning and reporting of cluster leaders, and provide advice to the MC on strategic issues regarding RTB.

Individual centers are responsible for managing their own scientists and ensuring that they are contributing to RTB in line with the performance agreements of the FP and for talent management of flagship and cluster leaders and gender focal points. The centers will be responsible for obtaining and maintaining bilateral grants to complement the W1/2 funds made available as part of the RTB scope of work for 2017–2022, subject to approval for their inclusion into the RTB portfolio by the PD.

7 MANAGEMENT BUDGET

The summary budget of RTB is presented in Table 4. Details by Sub-IDO are given in the Performance Indicator and Budget Matrix (see Annex 1). The total budget over six years is US $791 million, of which about $25 million, or 3.1%, is CRP and flagship project management cost. This includes an extended program management team, a 30% salary contribution, and administrative support for flagship project leaders and the costs of the ISC and MC.

Table 4. RTB management budget 2017–2022

Total RTB management budget 2017–2022	'000 US$
FP team (FP Leader, administrative assistants)	6,467
PMU Team (10.3 Full-Time Experts)	8,739
ISC - Independent Steering Committee	622
MC - Management Committee	1,665
Travel	895
Consultancy	415
Workshop/Training Support	796
General Supplies & Services	4,985
TOTAL	**24,583**

Some 10.9% of the R&D budget is invested in gender research and enabling actions to promote gender equity (Table 5). The estimated co-investments with other CRPs are $12–16 million/year, or 11–15% of the annual research costs in the flagships. Of the total budget, 46% is expected from W1/2 and 54% from Window 3 and bilateral grants.

Table 5. RTB total budget by FP and split by management and gender share

Flagship Projects	Budget Elements ('000 US$)		
	Total Budget 2017–2022	Management	Gender
FP 1: Enhanced genetic resources	157,558	4,895	7,878
FP 2: Productive varieties & quality seed	205,676	6,392	14,397
FP 3: Resilient crops	100,489	3,122	7,034
FP 4: Nutritious food & added value	73,359	2,280	5,135
FP 5: Integrated livelihood systems	165,309	5,138	24,796
FP 6: Impact at scale	88,720	2,757	26,616
TOTAL	**791,112**	**24,583**	**85,857**

This budget is based on the level of funding in the 2014 budget. Added to this was an estimate for funding for activities for the portion of livelihood system research previously managed by Humidtropics. This maps to RTB ($157 million, or 20%) and new Genebank added-value activities that were not previously covered ($43 million, or 5%). The budget assumes annual average growth in W1/2 revenue of 6.7% and for W3 and bilateral of 3.9% (annual average growth of 5.2% in total revenue). Assuming an inflationary increase of 2% over this period, this represents a real increase of under 3% per year.

PART 2: FLAGSHIP LEVEL

FLAGSHIP PROJECT 1: DISCOVERY RESEARCH FOR ENHANCED UTILIZATION OF RTB GENETIC RESOURCES

FP1 will develop and apply leading-edge science toward realizing substantially higher rates of genetic gain for end user-demanded traits. FP1 will add value to genetic resource collections through enhanced conservation, gene and trait discovery, use of diversity, and genetic improvement methods, to guide varietal and trait development pipelines for enhanced uptake and impact. FP1 comprises five clusters:

DI1.1 RTB breeding platform. Creates greater efficiencies by effective two-way communication about breeding targets, methods, and processes, pipeline products (populations and varieties), and competencies within RTB and with NARES, the private sector, and other users.

DI1.2 Next generation breeding for RTB crops. Develops advanced tools, methods, models, and systems to improve accuracy and scale of breeding and shorten selection cycles. DI1.2 develops efficient, high-throughput-omics tools and methods for trait and gene discovery and deployment. Analytical genetic and biometric tools and biostatistical models support proof-of-concept breeding research (e.g., genomic selection, genome-wide association studies, and use of RTB inbred lines in innovative breeding systems).

DI1.3 Genetically engineered RTB varieties with game-changing traits. Leads breakthroughs in transgenic and genome-editing technologies to accelerate genetic improvement of existing superior varieties, especially for traits that are intractable through conventional methods. The techniques directly introduce genes (i.e., transgenic, intragenic, cisgenic) to change the expression of endogenous genes (RNAi, silencing, editing) and to swap nucleotide sequences (Transcription activator-like effector nucleases, CRISPR).

DI1.4 Sustaining the evolution of RTB agrobiodiversity and benefits to custodian farmers through a global network of RTB in-situ conservation. Sustains farm production systems and supports rural livelihoods through the conservation of local genetic resources to meet future demands of farming and sustainable development. DI1.4 will develop a global network for in-situ conservation of RTB crops and some crop wild relatives (CWR), with best practices and monitoring systems, functional policies, and incentive systems.

DI1.5 Adding value to genebanks. The diversity conserved in the ex-situ RTB collections is the foundation for achieving the goals in this CRP. Complementing and working together with the Genebank CRP, which will cover routine maintenance and basic conservation improvements needed to bring the collections up to expected standards. DI1.5 enhances the value and use of the collections through research aimed at understanding and uncovering the diversity conserved there.

1. Grand challenges

Nutritious and diverse agri-food systems and diets. By 2050, population growth and changes in dietary preferences will more than double food demand in SSA, where people are highly dependent on RTB crops. Yield increases at farm level have generally not kept pace with demand, which is being radically affected by urbanization and increasing incomes. Research will support incorporation of new traits to revolutionize RTB crops—from locally produced, processed, and consumed products to those that are storable, transportable, convenient, nutritious, and affordable, and with linkages to animal-based production systems through feed.

Emergent and persistent pests and diseases. Emergence of new pests and diseases, pathogen evolution, and spread of current constraints such as cassava brown streak disease (CBSD) (and the associated vector, super-abundant whitefly), banana bacterial wilt, and potato late blight threaten livelihoods. An accelerated response is needed, especially the identification of molecular markers for resistance to speed breeding and the incorporation of diverse genes for durable resistance.

Climate change. Climate change will drive the demand for research on biotic and abiotic stresses. Disease and pest incidence will be shifted, and weather uncertainty (e.g., drought and flooding) will increase due to climate change. Several RTB crops are resilient to drought or floods, and can be further improved, creating the need for access to new genetic variation and for accelerated breeding. Climate change modeling will guide enhanced utilization of genetic resources. Crops will be bred for higher yield response to elevated levels of carbon dioxide.

Diminishing genetic resources. Genetic diversity of RTB land races and CWR—sources of novel traits and genes—are at risk from a wide range of drivers. These include replacement of traditional varieties by modern cultivars; agricultural intensification; and increased population, poverty, land degradation, and a changing climate. Improved management, collection, characterization, and use of material from ex-situ genebanks, coupled with support for in-situ monitoring and on-farm conservation, are central to a coordinated approach to meet this challenge of diminishing genetic resources.

2. Strategic relevance and comparative advantage

RTB scientists are uniquely placed geographically within the production and research environments of next and end users. The RTB centers have critically placed talent and infrastructure (labs, genebanks, greenhouses, and experiment stations) for seamless integration between discovery and delivery research. RTB scientists and partners, which are broadly based on the ground in target regions, will be the first to monitor and understand the impact of climate change on agricultural sustainability. Additionally, RTB has the capacity to develop broad partnerships at many levels—for example, from advanced labs in developed countries, to farmer associations in the poorest ones.

RTB recognizes the unique power of transgenics to overcome specific, targeted barriers to breeding and new opportunities offered by understanding and editing genomes. At the same time, it acknowledges the regulatory and public acceptance challenges associated with genetically modified organisms (GMOs). RTB has comparative advantages in genetic modification, primarily as the sole developer of technologies for crops with low industry interest in developing countries.

3. Enabling environment and Theory of Change

After proof of concept is established in FP1, the routine application of advances from DI1.1 – DI 1.5 will be integrated into, and delivered through, the Delivery Flagships. Feedback mechanisms, especially through the RTB Breeding Platform, and FP5, which considers the whole-system context, will keep gender-differentiated end user's needs at the forefront of research design from the outset.

The impact pathway of FP1 (Fig. FP1.1) is composed of Discovery products that generate a set of research outcomes with next users. In many cases, next users will be scientists in FP2 supporting crop improvement. FP1 will contribute to some Sub-IDOs in its own right; others will be accomplished with FP3–FP5. Figure FP1.1 shows key risks and assumptions for the logic of the ToC as well as CapDev interventions.

Women typically are the principal cultivators, processors, and marketers of RTB crops, especially in Africa. Varietal trait preferences such as texture, flavor, appearance, and nutritional value are often gender differentiated. A major challenge that RTB will address through foresight (FP6) and value chain analysis (FP2 and FP4) is understanding the evolving market drivers, differentiated by men and women market actors, in order to prepare technical responses 10–15 years in anticipation of need. For example, nearly all cassava peeling in West Africa is currently done manually, and mostly by women. Some traits facilitate hand peeling, or alternatively facilitate mechanized peeling. FP1 will link with FP6 to evaluate the possible consequences of the new technology and define gender-sensitive, development-oriented research strategies.

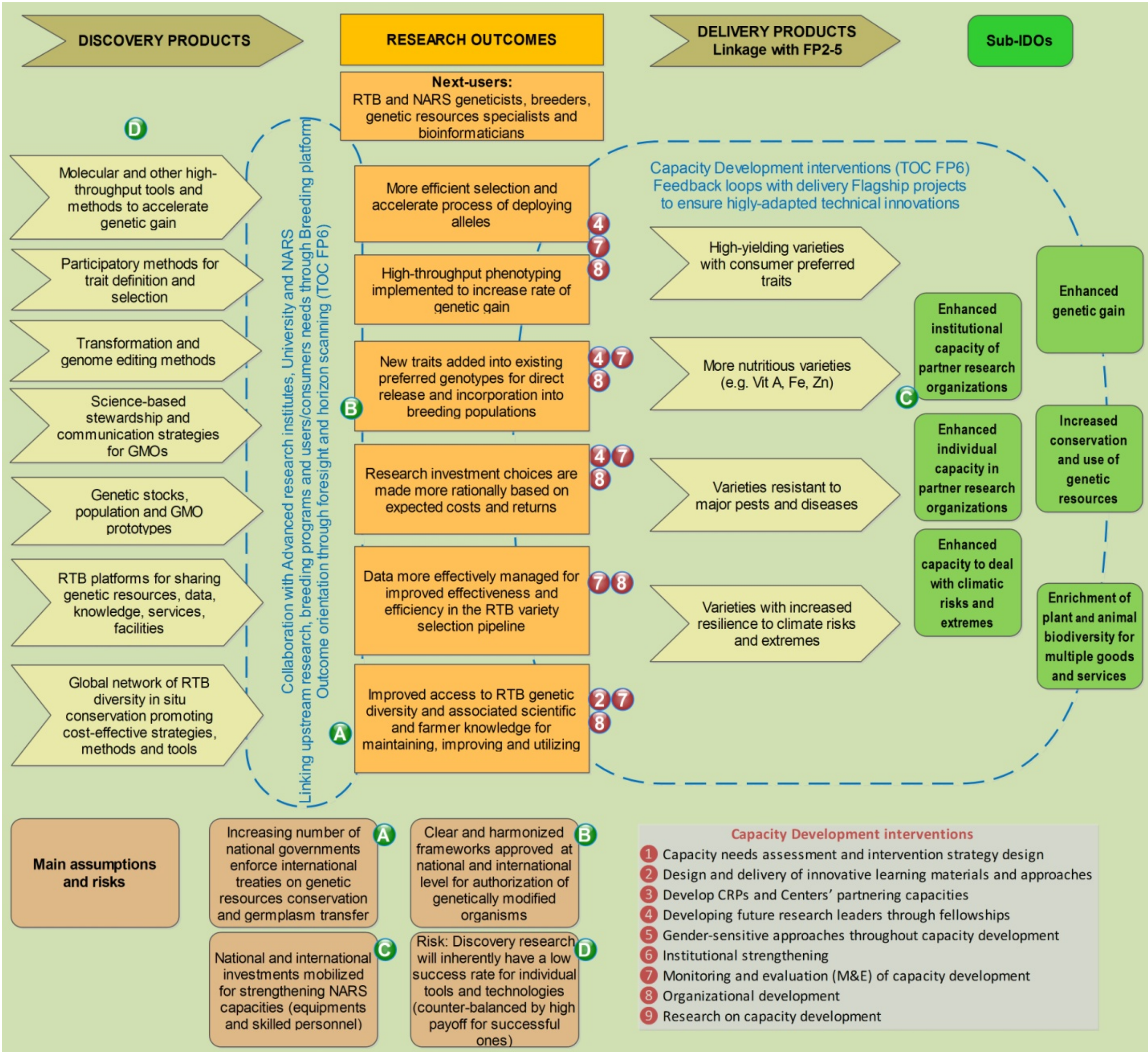


Figure FP1.1. Impact Pathway FP1—main risks/assumptions and capacity development interventions

4. Geography and beneficiaries

FP1 achieves Sub-IDOs via the Delivery FPs; most products are of global or regional relevance. As Discovery research and breeding takes several years, development outcomes will mostly occur post-2022. Hence, for this flagship, targets for genetic gain are identified at a regional level and are measured as research outcomes in multilocational trials (Table FP1.1). These will be tracked through the Breeding Platform, but are actually the combined results of activities in FP1, FP2, and to a lesser degree in FP3 and FP4, where some varietal selection will also take place.

Table FP1.1. Geographical target regions and metrics for genetic gain in FP1

Target Environment	Target Trait	Target Level 2022[2]
BANANA & PLANTAIN		
East Africa	Yield and earliness; drought tolerance; resistance to nematodes, weevil, Fusarium wilt, and BXW	3% per year yield increase, with drought tolerance; resistance to Fusarium wilt, nematodes, weevil, and BXW
West and Central Africa	Yield and earliness; drought tolerance; resistance to nematodes and weevils	3% per year yield increase, in early-maturing varieties; with drought tolerance; resistance to nematodes and weevils
Latin America	Yield; resistance to Black leaf streak (BLS) and Fusarium wilt	3% per year yield increase; with resistance to BLS and Fusarium wilt
Asia	Yield; resistance to BLS and Fusarium wilt	2% per year yield increase; with resistance to BLS and Fusarium wilt
CASSAVA		
Asia	Yield, starch content, new starches	>32%; functional properties for new starches
Latin America	High pro-vitamin A	> 20 µg beta-carotene
West and Central Africa	High carotenoids; high dry matter; poundable; low cyanogenic potential	2% per year increase in carotenoids content; 2% per year increase in dry matter content
West Africa	Yield, dry matter (high starch), CMD, and preemptive CBSD resistance	2% per year yield gains with high dry matter content
East Africa	Yield, dry matter, CMD and CBSD resistance; preferred culinary attributes	2% annual dry yield gains with combined resistance to CMD and CBSD
POTATO		
Tropical highlands and mid-elevation tropics: (Andes, Africa, Tropical Asia)	Earliness; drought tolerance; late blight (LB) resistance; insect resistance; biofortification with Fe, Zn, and vitamin C table-potato preference	90–110 days maturity (30% of area); drought tolerance in 20% of clones; moderate to high LB resistance in 20% of area; 45-ppm Fe and 35-ppm Zn; vitamin C, 130 mg/100g fresh weight
Subtropical lowlands: (Indo-gangetic Plains, China, Indochina)	Earliness; virus resistance; heat tolerance; long dormancy period; cold chipping ability; high dry matter content	70-day maturity in 30% of adapted population; combined resistance to PVY, PVX, and PLRV; 20% of lowland tropics adapted clones tuberizing at up to 25°C night temperature; 10 % clones with improved cold chipping ability; dry matter content, 18–22%
Temperate and mid-altitude agro-ecologies: (Asia, Africa, Latin America)	Yield, earliness; drought and salinity tolerance; virus resistance; salinity; and red skin	3% per year yield gains in 90-day potatoes; high resistance to PVY, PVX, and PLRV; salinity tolerance level in 20% of clones; red skin in 50% of clones
SWEET POTATO		
Africa–Tropical and sub-tropical lowlands and mid-elevation tropics	Yield and earliness	3% per year yield gains with 120-day maturity; orange flesh
	SPVD resistance	10% SPVD resistance in orange breeding populations
	Adaptation to drought-prone environments	Among drought-resistant orange clones 20–30% respond to rains
S&SE Asia -Tropical and sub-tropical lowlands and mid-elevation tropics	Non-sweet; storability Yield and earliness; orange flesh color; and dry matter	Sucrose 6% dry weight basis 3% per year yield gains for 100-day orange sweetpotatoes; Beta-carotene 150 ppm dry weight basis; dry matter 31%
YAMS		
West Africa	Yield; earliness; dry matter; anthracnose resistance; nematode resistance	3% per year yield increase; anthracnose and viruses resistance; reduced postharvest losses by 30%
Other Regions: Asia, East Africa, Latin America, and the Pacific	Yield earliness; tuber quality; anthracnose resistance; yam mosaic virus resistance	Genetic diversity characterized; superior parents identified; 1.5% per year yield increase; breeding for quality and resistance target traits initiated

[2] Targets generally defined as those levels achieved in extensive on-farm, farmer-managed multilocation trials throughout the target region.

5. Novelty of science

The Discovery FP will innovate in a fast-evolving scientific environment where DNA-level characterization, digitalization, automation, and big data are pillars of creation of new technologies. The new breeding technologies will allow RTB to react more quickly to producer, market, and consumer demands, and create greater efficiencies in breeding (Pérez-de-Castro et al. 2012).

DI1.1: Breeding platform. The breeding platform will capture synergies among a wide range of scientists through, for example, shared genotyping, high-throughput phenotyping, and bioinformatics platforms. It will address the persistent, low level of interaction among breeders, molecular biologists, genebank curators, and social scientists. The platform will include capacity building; development of metrics; bioinformatics to connect phenotype to genotype; tools for precision field breeding; and documentation, communication, and promotion for use of breeding materials. It will serve as a community of practice among breeders and will ensure that men and women farmers are involved early in the selection process to facilitate adaptation of new varieties and impact. The platform will prioritize multidisciplinary and multipartner work to phenotype germplasm collections for desirable traits, especially for needed response to climate change, changing production, processing, and market needs.

DI1.2: Next-generation breeding. RTB crop improvement is particularly complex due to clonal propagation, which maintains both heterozygocity and deleterious alleles. For some of these crops, polyploidy creates additional complexity. DI1.2 will exploit multiple tools and methods that confront this complexity. Examples include metabolome and proteome profiles (i.e., stress, flavor, and texture traits); high resolution genome mapping (to link key traits with selectable markers); genomic selection (formation of a training population for estimating breeding value); genome-wide association studies (identification of quantitative trait loci studies and discovery of novel traits); development of platforms for high-volume data management (expansion of initiatives such as cassavabase.org to the other RTB crops); population improvement methods such as doubled haploid systems, limited in-breeding, and new trait transfer (allowing for systematic exploitation of heterosis); and high-throughput phenotyping linked to aerial imagery (e.g., drones; terrestrial laser scanning) and ground-penetrating radar to select for growth and development traits.

DI1.3: Game changing traits. Transgenic approaches can add key traits without changing the existing genetic background of grower- and consumer-preferred traits. Initial targets will be resistance to significant biotic constraints—specifically, *Xanthomonas* in cassava, *Ralstonia* in potato, and *Xanthomonas* in banana—where success with conventional breeding has been limited. The cluster will focus on novel genetic modification technologies, proof of concept, and prototypes. Genome editing uses the bacterial recognition target gene sequences to elicit resistance (e.g., SWEET gene for *Xanthomonas*, or cell death like the bs2 gene for *Ralstonia*) (Gaj, Gersbach & Barbas 2013). RTB intends to complement the science with communication and advocacy to fill the need for a more coherent/coordinated, innovative, and pro-active strategy and voice on crops with such traits incorporated.

DI1.4: In-situ conservation. In-situ monitoring is of utmost importance as environments, traditions, and habitats are changing and vanishing forever, eliminating the biota they contain with them. Monitoring will include diversity analysis and cultivar/species identification coupled with meta-analysis of grower, processor, and consumer-linked information for landrace varieties. An important focus will be with in-situ conservation and monitoring of habitats of the CWR, which are under high risk of genetic erosion in their widespread natural habitats. Important gender dimensions of in-situ management involve seed selection, farmer cuisine, and preference traits (drivers of conservation); nutrition; marketing; crop exchange; folk taxonomy; and feminized conservation where male migration occurs.

DI1.5: Adding value to genebanks. In close complementarity with the Genebank CRP, there are many research needs for enhancing value from use and the development of novel long-term conservation methods that are beyond the scope of the proposed Genebank CRP. Such research includes conservation research to understand and enhance seed longevity; cryo-conservation; support to digital genebanks; new collections of landraces or wild species; and linking genes or traits to genebank accessions. Detailed accession-specific genomic-linked phenotypic information is needed to identify new traits, for adaptation to climate change, pest and disease resistance, and consumer-preferred quality attributes for inclusion in pre-breeding programs in FP2. Predictive characterization will allow rapid screening of germplasm, making the breeding and other end user processes more efficient and cost effective. High-density marker diversity analyses of genebanks will help to identify evolutionary gene pools, which in turn can aid breeders in selecting best parents to maximize heterosis or for specific trait expression. Selfing and germplasm enhancement using genebank accessions will allow expression and selection for hidden recessive traits.

6. Previous projects/activities

At the beginning of Phase I, RTB initiated small-scale genotyping of genebank accessions and certain improved populations to (1) understand the organization of global genetic diversity of the cultivated species and CWR (Tessema et al. 2014), and (2) link specific traits of interest to genetic markers by means of statistical approaches to identify functional variation as a way of facilitating and accelerating selection. DGD Belgium led a project in cooperation with Bioversity and KU Leuven on “Adding value to the ITC banana collection through molecular and phenotypic characterization.” The project supports phenotyping and omics (transcriptomics/proteomics) and gene discovery related to drought tolerance in a core set of banana cultivars (Folgado et al. 2013, 2014; Vanhove et al. 2015).

Discovery research also focused on developing and integrating genomic, phenotypic, and metabolomic databases and testing the feasibility of applying novel genomic approaches. Genome-wide association, genomic selection for gene discovery, and phenotypic predictions toward accelerated genetic gains were carried out in cassava, banana, and potato breeding programs (Cenci et al. 2014; Lindqyist-Kreuze et al. 2014; Rabbi et al. 2014a, 2014b). Proof-of-concept work at CIP demonstrated the potential of genomic selection as a powerful tool for accelerating potato breeding progress for early bulking under warm temperatures and long photoperiods, and for increasing accumulation of minerals from diploid landrace germplasm. Research on metabolomics with RHUL has produced customized metabolite profiling libraries for all RTB crops. Potential species-specific biomarker metabolites associated with traits conferring tolerance to environmental stress as well as agronomic and consumer traits have been identified/ postulated.

CBSD has quickly emerged as a major threat in East Africa, and is moving westward. Proof-of-concept work at Danforth Center, USA, and ETH, Switzerland, together with NaCRRI, Uganda, has demonstrated efficacy of transgenic approaches. Similar likely successful prototypes and GMO products are underway for banana and potato (Kyndt et al. 2015; Nyaboga et al. 2014). In Africa IITA, in collaboration with NARS, has transformed banana for resistance to nematodes and *Xanthomonas* wilt; cassava for virus resistance; and yam and enset in Kenya and Ethiopia, respectively, as proof of concept.

Previous work on in-situ conservation of RTB crops has mainly concentrated on landraces and been conducted in the Andes (potato), South-east Asia (sweetpotato), and the Pacific (taro). For several years CIP and CIRAD have targeted baseline documentation of intraspecific diversity in selected monitoring hotspots in Peru, Bolivia, Vanuatu, and Indonesia toward evidence-based long-term monitoring of the conservation status of landraces and RTB CWR (De Haan et al. 2014; Särkinen et al. 2015).

The Global Crop Diversity Trust and the Millennium Seed Bank of the Royal Botanic Gardens, Kew, CIP and CIAT analyzed gaps in ex situ collections of potato and sweetpotato CWR. 11 out of 14 (78.6%) and 32 out of 21 (43.8%) species of sweetpotato and potato CWR included in the analyses were assigned high priority status for future collecting (Castañeda-Álvarez et al. 2015; Khoury et al. 2015).

Successful initiatives to enhance in situ conservation focused on providing incentives through value chain development (niche markets), repatriation of genetic resources to sites where loss was reported, as well as pilot-level monetary benefit-sharing cases with private sector investment (i.e., through AGUAPAN in Peru).

RTB piloted an RBM strategy for Next-Generation Breeding, launched with an expert workshop (RTB 2015) with CGIAR participants, advanced labs, private sector, and universities. This provided guidelines to align Discovery research with end users' needs and priorities, and to establish the collaborative networks for cost-effective research. An M&EL system was proposed to capture metrics for upstream research, where there is typically a long lag time between the research and results from its application leading to impact.

7. Partnership strategy

An existing broad range of partners provides the key multidisciplinary expertise, capability, and research resources to deliver tools, information, and characterized genetic diversity and gains to next users (Table FP1.2). Developed countries have a lead on developing and deploying cutting-edge technologies. RTB supports North-South and South-South partnerships that maximize access, implementation, and CapDev for discovery research in developing countries.

RTB will co-invest with other AFS-CRPs (RAFS, MAIZE, WHEAT, DCLAS) to share genotyping, high-throughput phenotyping, and bioinformatics platforms. The Genebanks CRP will be a critical co-investor with RTB for integration of gene discovery, germplasm enhancement and pre-breeding, and in-situ research. With Global Integrating programs, CCAFS and RTB will co-invest to develop climate-sensitive breeding strategies, under the CCAFS Learning Platform "Foresight, models and metrics for climate-sensitive breeding." This effort will especially integrate climate change models into trait prioritization for regions (e.g., drought tolerance, heat tolerance, and pest and disease resistance). RTB will link with each of the research activities proposed by CCAFS for climate-sensitive breeding (see Annex 6).

Table FP1.2. Key partnerships for FP1

Partner or player	Role in developing product or achieving outcome
Universities/ Agricultural Research Institutions (ARI)	
Royal Holloway University of London (RHUL), UK	Metabolomics analysis (ongoing diversity assessment) and metabolite profiling for defined quality traits
Kasetsart University, Thailand	Development of markers for pest and disease traits
Martin-Luther-Universität Halle-Wittenberg, Germany	Genome editing tools and methodologies
Freiburg University, Germany; RHUL	Elucidate pathways and develop markers for carotenoids
Cornell University/Boyce Thompson Institute, USA	Data management tools for genotyping, linked to breeding; genotyping by sequencing; genomic selection
University of Birmingham, UK Agropolis Foundation, France	On-farm and in-situ conservation; systematic monitoring of landrace and CWR diversity
Sybioma, KU Leuven, Belgium	Facility for systems biology-based mass spectrometry; proteomics platform, characterization of peptides linked to stress responses (already applied on banana and potato); drought phenotyping for banana
Global Crop Diversity Trust	Conservation and collection of CWR; DivSeek Initiative to link genebank genomics and phenomics
National Research Systems	
NaCRRI, Uganda, NRCRI, Nigeria	Genomic selection cassava and yam (only Nigeria); protocols for doubled haploid production

Partner or player	Role in developing product or achieving outcome
KALRO, Kenya	GM field crop testing
Embrapa, Brazil	Development of high-throughput phenotyping; in situ conservation
CAS, CATAS, China	Development of markers for quality traits; induction of flowering
CTCRI, India	Trait discovery for starch functional properties and non-root uses for RTB
INIA system (Peru, Bolivia, Chile)	On-farm/in-situ conservation; incentive mechanisms; systematic monitoring of landrace and CWR diversity
CRI/SARI, Ghana	Yam breeding
BecA, Kenya	Research and capacity development in Central and Eastern Africa
BGI, China	Genotyping by sequencing and re-sequencing
CGIAR CRPs (see also Annex 6)	
AFS-CRPs	Shared genotyping, high-throughput phenotyping and bioinformatics platforms
CGIAR Genebanks	Gene discovery and in situ
CCAFS	Trait discovery and prioritization for traits for climate change adaptation
A4NH	Elucidate pathways and develop markers for carotenoids

8. Capacity development

Building advanced science capacity is a key part of achieving impact through discovery research for RTB. CapDev involves individuals, organizations, and networks; developing the linkages between these components is a key goal. Current partners are mainly from developed country labs. Stronger participation in the process by countries who are intended beneficiaries, through CapDev, is key to sustainable success.

FP1 will emphasize **development of learning materials** through participatory engagement among partners to source, compile, and disseminate according to specific capacity and needs. Universities involved as partners in RTB Discovery, have particular expertise and linkages for CapDev. Partnerships with NARES for confined field trials and risk assessment will be important for game-changing trait activities. Capacity for data analysis and intellectual property, open data, and communications are essential for enabling Discovery CapDev. The RTB Breeding Platform prioritizes and coordinates CapDev.

Short- and long-term staff exchanges will be integral to CapDev. For example, RTB Discovery could benefit from at least one senior scientist exchange (1–3 months) every 1–2 years, and a longer term sabbatical leave (e.g., from partner university labs) at an RTB center every 1–3 years. Training at the MSc and PhD level will be sought in bilateral projects, in priority topics for RTB. Preferentially, these candidates should be from key RTB countries, and with strong support to women scientists.

To enhance institutional capacity of partner research organizations, greater use will be made of regional initiatives such as BeCA. In West Africa and in the Americas, IITA and CIAT/CIP, respectively, strongly encourage and support access to their advanced labs. Strengthening labs within the CGIAR centers as regional platforms will complement and fill gaps for national partners. Asia has some of the world's most advanced labs for RTB work, especially in India and China, but also in Thailand and Vietnam. These countries are key RTB producers, and their participation in regional CapDev will be actively supported.

Gender-sensitive approaches are needed for Discovery CapDev. Fortunately, in recent years there is a strong interest and success around the world of women earning advanced degrees in science. This is greatly helping to set the foundation for future success in gender-sensitive strategies.

FLAGSHIP PROJECT 2: ADAPTED PRODUCTIVE VARIETIES AND QUALITY SEED OF RTB CROPS

FP2 aims to develop and make available good-quality planting materials of a diverse set of high-yielding RTB varieties that are adapted to the needs and preferences of users in value chains. FP2 will use participatory, gender-sensitive tools to understand the traits and criteria that stakeholders use for the adoption or rejection of varieties. End user intelligence (with FP4 on consumer preferences and sensory testing) will guide breeding processes, to ensure integration of novel breeding targets, such as traits linked to nutritional quality or processing. Predictive modeling and foresight work will assess future production, processing, and consumption needs that would be unlikely criteria for current end users, to ensure that breeding takes into account future needs for RTB varieties. FP2 includes seven clusters:

CC2.1: Improving smallholder access to healthy RTB planting material and new varieties. Will improve the quality of RTB seed system interventions across all crops, through the development of evidence-based tools and frameworks for seed system stakeholders. It will both contribute to and learn from seed-related work in crop-specific clusters in FP2–FP4 and in a livelihood context in FP5.

BA2.2: Matching banana cultivars and hybrids with farmers', consumers' and markets' needs, for more sustainable food and production systems. Will sustainably increase banana productivity by developing cultivars that better fit key stakeholders' needs and preferences, and make them available to key actors in the banana value chain.

CA2.3: Added-value cassava varieties for traditional uses and high-impact markets. Will deliver improved cassava varieties that meet the needs of growers, processors, and consumers who depend on cassava for their diet and/or income generation. It will have strong linkages for user adaptation with cassava clusters in FP3 and FP4.

PO2.4: Improving livelihoods of potato farmers in Africa by tackling deteriorated potato seed quality through an integrated approach. Will facilitate innovative business arrangements at key points along the potato seed value chain that increase access to quality planting material and robust varieties.

PO2.5: Agile potato for Asia. Will provide alternatives for improving productivity and intensifying and diversifying cereal-based systems and smallholders' livelihoods in target areas of Asia, through the development and utilization of potato varieties adapted to multiple cropping systems.

SW2.6: User-preferred sweetpotato varieties and seed technologies. Will deliver improved sweetpotato varieties meeting diverse user preferences and needs with gender-responsive seed systems and strong linkages to SW4.4, which focuses on achieving nutritional outcomes

YA2.7: Yam varieties and sustainable seed systems. Will develop end user-preferred yam varieties, adapted to diverse cropping systems, deployed through an improved and sustainable seed system.

1. Grand challenges

Producing sufficient nutritious food. More than 800 million people remain acutely or chronically undernourished, and the number suffering from micronutrient deficiency is even greater. Increased yield, in terms of calories and micronutrient content, will help to reduce hunger and malnutrition. RTB breeders will ensure that taste and nutritional issues are carefully evaluated when developing new varieties, along with expanded efforts to take user-preferred varieties to scale.

Climate change and risk of biodiversity loss. The genetic resource base needed for future food production for the growing global population is increasingly threatened, further aggravated by the impact of climate change. FP2 will exploit the existing diversity of RTB crops both directly and in crop improvement programs, to identify and generate varieties with wide adaptation. These include resistance to newly emerging pests and diseases as well as tolerance to drought, heat, salinity, and extreme events linked to climate change.

Soil degradation. Low productivity often drives the expansion of the frontier of cultivation onto marginal lands prone to soil degradation. Through the cultivation of more productive RTB varieties that make more efficient use of external inputs, FP2 will contribute to reducing pressure on land and water.

Postharvest losses and value-addition opportunities. RTB crops are often perishable and highly prone to postharvest loss. Varieties will be developed that store better and deteriorate slower after harvest, and are adapted to novel processing opportunities.

New entrepreneurial and job opportunities. FP2 will open up new opportunities for women and men for employment and income generation through the profitable sale of diverse, locally available, high-quality RTB seed. Through a demand-driven process, RTB will collaborate with a broad range of partners to achieve equitable access to varieties and seed, and related information, as well as business opportunities.

2. Strategic relevance and comparative advantage

RTB offers the combined assets of scientists from Bioversity, CIAT, CIP, IITA, and CIRAD, and a strong strategic partner network from advanced research institutes, national programs, private sector, NGOs, and women's alliances and networks to synergistically address the challenges of varietal improvement and seed distribution of clonal crops. The main comparative advantage of RTB is the extensive genetic resources base and hundreds of accumulated years of research experience with conventional breeding. Linked to progress made in other crops and advances coming from the Discovery FP1—and further combined with the experience and progress in seed systems—FP2 will accelerate the development of and significantly increase the effective uptake of RTB varieties.

Unintended consequences. FP2 will pay close attention to socioeconomic factors that may affect varietal preferences, or that may restrict availability of new varieties and quality planting material to specific stakeholder groups. RTB will implement gender-responsive approaches to increase equitable access to seed of varieties with appropriate traits for food security and markets. Attention to how the introduction of new varieties could impact women and youth in positive or negative ways will be addressed. Sex-disaggregated data will be collected and analyzed to inform varietal selection and seed production decision-making that is gender responsive and, ideally, gender transformative. Results will enable women and vulnerable households to fulfill their roles in food provisioning, production, and income generation.

3. Enabling environment and Theory of Change

The impact pathway of FP2 (Fig. FP2.1) comprises products that generate research outcomes with next users. Often, next users will be in FP3–FP5 where client-oriented varietal selection will be needed to incorporate varieties into resilient cropping systems, processing opportunities, and nutrition-responsive value chains and programs. Also, CC2.1 as a crosscutting cluster supports and learns from research in crop-based clusters in FP2 but also in FP4 and FP5 (e.g., modeling of seed degeneration can guide protocols for seed replacement for varietal uptake). Hence, FP2 will contribute to some Sub-IDOs in its own right, while others will be accomplished with FP3–FP5. Figure FP2.1 shows key risks and assumptions for the logic of the ToC to play through, as well as capacity development interventions.

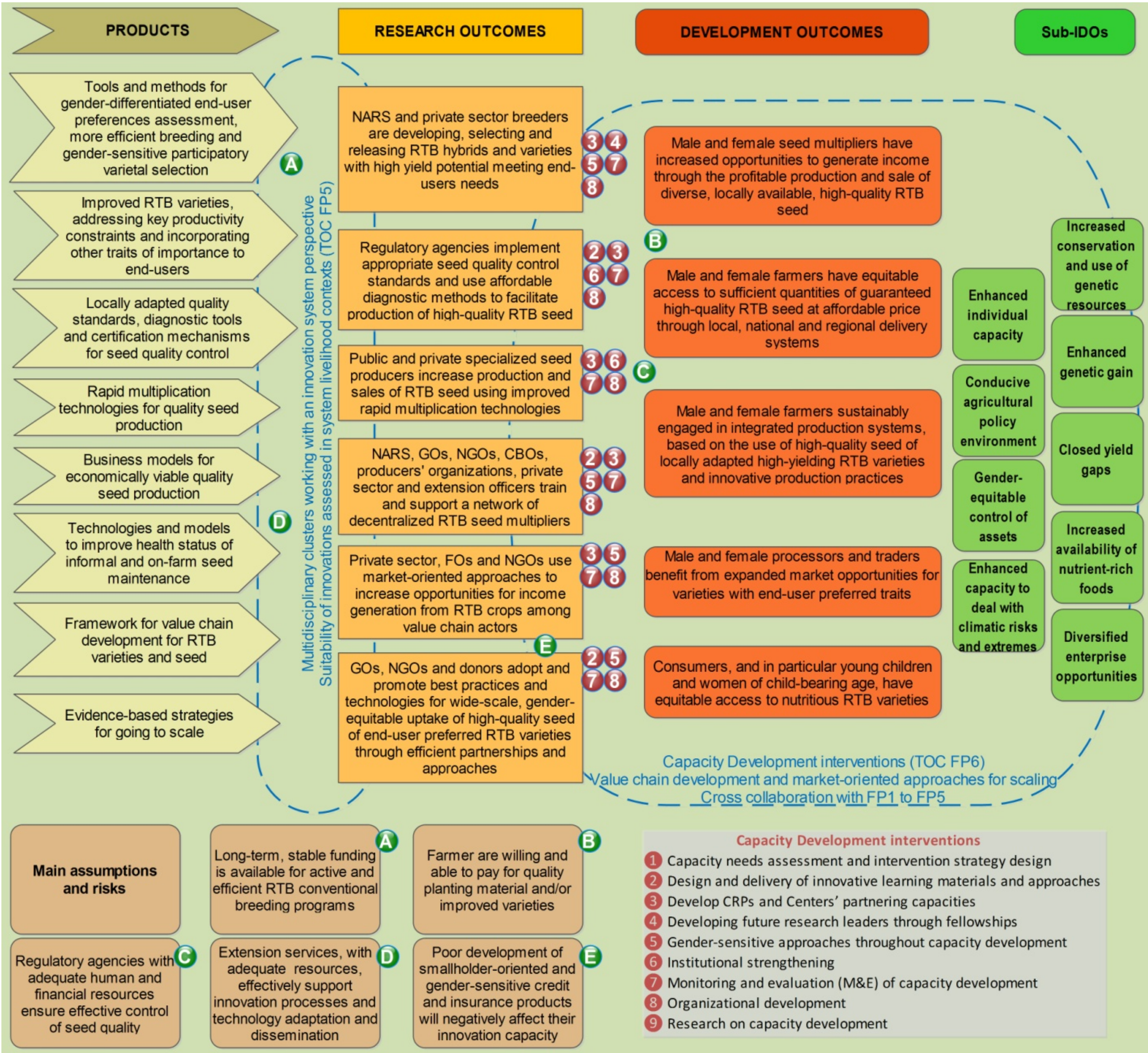


Figure FP2.1. Impact Pathway FP2—main risk/assumptions and capacity development interventions

4. Geography and beneficiaries

Targeting is guided by (1) importance of RTB crops for food security and livelihood of vulnerable people, with specific attention for women and youth; (2) size of yield gap of RTB crops; and (3) opportunities for varietal adoption and improved seed systems to solve these challenges. Selected (Sub)-IDOs with quantified targets for 2022 are presented in Table FP2.1. Breakdown of targets by Sub-IDOs as well as targets related to crosscutting issues can be found in Annex 1.

Table FP2.1. (Sub)-IDOs, beneficiaries, and target countries for FP2

Target IDOs & *Sub-IDOs*	Total number of beneficiaries (2022)	Target countries
Increased productivity ***Increased conservation and use of genetic resources***	Yield increased at farm HH level **BA2.2**: 3,000,000 HH: 10–15% yield increase **CA2.3**: 2,800,000 HH: 20–50% yield increase **PO2.4**: 660,000 HH: 20–40% yield increase **PO2.5**: 1,280,000 HH: 7–40% yield increase	**BA2.2** **Africa:** Burundi, Cameroon, Ivory Coast, DRC, Gabon, Ghana, Guinea, Kenya, Nigeria, Rwanda, Tanzania, Uganda **Americas:** Brazil, Colombia, Costa Rica Ecuador,

<table>
<tr><th>Target IDOs & Sub-IDOs</th><th>Total number of beneficiaries (2022)</th><th>Target countries</th></tr>
<tr><td>Enhanced genetic gain
Closed yield gaps through improved agronomic and animal husbandry practices</td><td>SW2.6: 2,000,000 HH: 50% yield increase
YA2.7: 1,200,000 HH: 40% yield increase
Postharvest losses reduced at farm HH level
YA2.7: 400,000 HH: 50% reduced postharvest losses</td><td rowspan="3">Cuba, Dominican Republic, Haiti, Honduras, Mexico, Nicaragua, Panama, Peru, Venezuela
Asia: India, Indonesia, Philippines
CA2.3
Africa: Cameroon, DRC, Ghana, Kenya, Malawi, Mozambique, Nigeria, Sierra Leone, Tanzania, Uganda, Zambia
Americas: Brazil, Colombia, Cuba, Ecuador, Haiti, Paraguay, Peru, Venezuela
Asia: Cambodia, China, India, Indonesia, Laos, Philippines, Thailand, Vietnam
PO2.4
Africa: Burundi, Cameroon, DRC, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda
PO2.5
Asia: Bangladesh, China, India, Indonesia, Kazakhstan, Nepal, Uzbekistan, Vietnam
SW2.6
Africa: Angola, Benin, Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda, Zambia
Asia: Bangladesh, India, Indonesia, Papua New Guinea
Caribbean: Haiti
YA2.7
Africa: Benin, Ghana, Ivory Coast, Nigeria, Togo</td></tr>
<tr><td>Increased incomes and employment

Diversified enterprise opportunities</td><td>Annual income/ha increased
CA2.3: 14,000,000 people – $116 (average)
PO2.5: 6,4000,000 people – $171 (average)
YA2.7 1,200,000 people – $700 (average)
Diversified opportunities for income generation in RTB value chains enhanced, especially for women and youth
BA2.2: 50,000 women entrepreneurs
PO2.4: 1,000 seed multipliers
YA2.7: 4,000 seed multipliers</td></tr>
<tr><td>Improved diets for poor and vulnerable people

Increased availability of diverse nutrient-rich foods</td><td>Annual production increased
PO2.4: 3–5% in target countries
PO2.5: 12% in cereal-based systems
Availability of nutrient-rich foods
BA2.2: Vitamin A-rich banana cultivars available for 500,000 people
PO2.4: Micronutrient-dense (Fe & Zn) potatoes available to 20,000 people</td></tr>
</table>

5. Novelty of science

Pre-breeding will be used to identify desirable characteristics and/or genes from CWR and other unimproved materials and to transfer these traits for breeders' use. In close collaboration with the RTB Breeding Platform, novel breeding targets, methods, and processes will be applied to accelerate breeding gains, make selection more accurate and shorten breeding cycles. Next-generation selection models, supported by bio-statistical tools, will be used for early, marker-assisted selection for target traits. Non-invasive high-throughput phenotyping tools will further enhance selection efficiency. Robust and cost-effective propagation systems will be developed to move quickly from breeders' seed to foundation seed.

Adoption of standardized designs and protocols for the evaluation of materials for adaptation to biotic and abiotic conditions, in combination with novel data capture tools and globally accessible data storage platforms, will allow the quantification of complex genotype by environment interaction over space and time. Crop modelling and Geographic Information Systems (GIS) tools, in combination with climate data, will be used to identify current and future homologous target environments to extrapolate varietal performance. Cross-analysis with socioeconomic data will allow better targeting to expected end user environments. Gender-responsive participatory varietal selection (PVS) methods will be mainstreamed to sustain adoption of new RTB varieties targeted to agro-ecological and socioeconomic context of end users.

FP2 will strengthen seed inspection and improve disease diagnostics in formal and informal seed systems. Supply chain management and risk prevention in RTB seed systems will be studied, resulting in more accurate seed supply and demand forecasts, and business models for profitable RTB seed production and delivery. Scaling mechanisms will be analyzed in differing contexts, and the national and regional policy environment mapped as it pertains to RTB seed, with suggestions for more efficient implementation.

CC2.1 Quality seeds and access to improved varieties. Novel cost-effective rapid multiplication technologies adapted to specific geographical and socioeconomic circumstances will be developed, to shorten seed production cycles. Modeling and impact network analysis will combine biophysical and socioeconomic data to characterize seed degeneration and generate decision support tools for seed systems interventions. Scientific evidence about seed degeneration will make it possible to accurately forecast seed supply and demand, and to more efficiently allocate resources. On-site diagnostics for rapid decision-making on plant health status will be developed. Novel approaches based on next-generation sequencing will be used to fast-track production of clean planting materials. Cost-benefit analyses of protocols for seed quality standards at national level, and seed quality control schemes for resource-poor conditions will be developed, including policies that promote community level seed businesses.

BA2.2 User-preferred banana cultivars/hybrids. Gender-sensitive assessment of end users' needs and preferences, in combination with PVS approaches, will ensure that traits of importance to end users are integrated into breeding and varietal selection processes. Crowdsourcing will be pioneered as a more cost-effective alternative to PVS. This will permit more farmers to be involved by reducing the scientific supervision needed, travel costs, and the number of varieties that each individual farmer evaluates, making it easier to scale to thousands and eventually millions of farmers. The cluster will more fully exploit the existing diversity of the crop, by tapping into local traditional knowledge, through the use of novel characterization and high-throughput phenotyping methods, and through an increased understanding of adaptation of landraces to local agro-ecological and socioeconomic conditions and their contribution to nutrient (Davey et al. 2009).

CA2.3 Added-value cassava varieties. Inbreeding will be introduced in cassava genetic enhancement, and homozygous cassava lines will be developed and exploited for breeding, especially through doubled haploids. The cluster will fully exploit modern genetic tools after proof of concept in FP1, such as genomics and metabolomics for early-generation selection for key user-preferred traits. Advanced high-throughput phenotyping tools will be used, such as ground-penetrating radar to assess root bulking rate and remote sensing with drones for measuring physiological responses. Sustainable commercial and on-farm seed systems will use strengthened seed inspection and low-cost pathogen-testing systems for delivering demanded varieties, supported by applicable national legal frameworks. Site-specific, climate-smart practices will be applied at small-scale farm level through farmer associations.

PO2.4 Potato quality seed. Novel tools will be used for accelerated breeding, such as molecular profiling of varieties, determination of genomic estimated breeding values of progenitors, and deployment of determinants responsible for resilient, high stable economic yield. Trait marker association studies will identify molecular markers associated with yield, quality, and tolerance parameters under varying conditions and integrate these for yield prediction and precision breeding. Germplasm will be phenotyped for traits of economic and nutritional importance in different stress scenarios and management options. Low-cost, off-the-grid, seed storage solutions will be investigated, and novel chemical and biological control technologies of postharvest pests/diseases will be validated. Diagnostics for rapid decision-making on plant health status will be developed, such as non-invasive spectral imaging-based systems and loop-mediated amplification (LAMP) diagnostics in the lab and field. Different business models will be tested for seed production based on combinations and levels of seed purchases, saving seed on-farm using differing technologies, and traditional farmer seed.

PO2.5 Potato varieties for Asia. Biophysical and socioeconomic models will be combined to target short-cycle potatoes more efficiently in various agro-ecosystems, integrated into rice or wheat cropping cycles. Models based on genomic selection will be applied to improve populations for earliness, rate, and duration of tuber bulking; adaptation to drought, heat, and salt, and late blight; in addition to yield and quality traits. Next-generation sequencing will be used to identify new viruses to guide breeding, and for risk assessment and phytosanitary guidelines, as well as the design of low-cost, more efficient diagnostic tools. Portable disease diagnosis tools will be developed for in-situ quality control of planting materials. Crop and system modeling for current and future agro-ecological conditions and market trends will facilitate targeting of new varieties to locations with higher likelihood of adoption. Remote and proximal sensing will aid phenotyping, monitoring adaptation to stress situations, yield forecasting, and land use changes.

SW2.6 User-preferred sweetpotato varieties. High-throughput phenotyping methods will be used to define and construct heterotic pools for specific traits, such as resistance to weevil and sweetpotato virus disease, drought tolerance, and nutrition quality traits. Molecular markers, linked to these traits identified through quantitative trait loci and genome-wide association approaches in FP1, will be used in marker-assisted accelerated sweetpotato breeding scheme for developing robust, resilient, and nutritious varieties. Genomic selection will be implemented as a sweetpotato population improvement strategy based on genomic-estimated breeding values predicted from phenotypic data from traits and genome-wide sequence-based markers. Implementation of marker-assisted and genomic selection in sweetpotato will contribute to faster genetic gains and identification of candidate varieties. New and innovative in-clone breeding will be (1) the accelerated breeding scheme in a CGIAR-NARS breeding network, (2) heterosis-exploiting breeding schemes, and (3) fast through-put virus stress/resistance and drought and salt stress/resistance screening.

YA2.7 Quality seed yam: Robust, cost-effective, high-ratio propagation systems, such as bioreactor systems and aeroponics, will be used, while novel approaches based on sRSA (NGS-based) and chemotherapy will fast-track production of clean planting materials. The development of on-site diagnostics and non-invasive spectral imaging-based systems will allow rapid decision-making on plant health status. New therapy procedures to eliminate fungi, bacteria, and nematodes from seed and ware yam will be validated. The yam phytobiome and its effect on tissue culture plants will be studied. Locally available materials will be tested for the construction of affordable, improved storage structures for seed and ware yam. Increased value chain knowledge will help to expand opportunities for yam processing and marketing (new food, feed, and industrial products). A gender-sensitive understanding of the market demand, in combination with forecast models, will allow a better assessment of input requirements and outputs to markets for better planning and increasing remuneration.

6. Previous projects/activities

RTB partnered with the BMGF funded NEXTGEN Cassava project to promote gender-responsive research on farmers' trait preferences in Nigeria and Uganda. This contributed to genomic selection breeding for resistance to cassava viruses and use of economic-weighted selection indices with the aim to ensure new varieties have wide and gender-equitable impact (Ly et al. 2013; Tecle et al. 2014; Rabbi et al. 2014).

RTB has developed next generation breeding systems based on the collection and application of genetic, metabolite, and phenotype data to genetic diversity and RTB breeding. This work helped to lay the foundation for efficient application of marker-assisted breeding, phenotypic selection, and hybrid development in RTB crops (Ceballos et al. 2015).

Conventional banana breeding by RTB centers and partners (Ortiz and Sweenen 2014) has resulted in high-yielding hybrids. A suite of NARITAs (Tushemereirwe et al. 2015) are being evaluated on farm as part of an ongoing BMGF project: "Improvement of banana for smallholder farmers in the Great Lakes Region of Africa." This project, partnering with national breeding programs, is developing tools to increase hybrid production and accelerate selection, participatory on-farm testing, and database development.

An RTB cross-center project to improve the management of seed degeneration brought together scientists and partners to understand the dynamics of degenerative diseases and effective control strategies. Collaboration led to preliminary seed degeneration process models. RTB also funded a cross-crop initiative to develop a conceptual framework that will be used to assess and improve seed system interventions to improve the availability of low-cost, high-quality planting material for farmers

In Kenya, the USAID-funded 3 generation (3G) project supported Kisima Farm in its efforts to specialize in early generation seed potato production. Kisima Farm now produces 1,600t of seed potato each season; invested in aeroponics to produce 200,000 minitubers annually; and invested in a 1,000t capacity cold storage facility. Technical backstopping and early efforts to encourage investment by CIP were essential to Kisima Farm's success. This is linked to a network of seed out-growers, many of whom are women. Farmers using quality seed have seen their yields double, and accompanying livelihood benefits (Ahmed 2015).

The RTB project on integrating gender into thematic research showed that seed systems approaches should embed methods and tools to address social practices that avoid the exclusion of women and other groups from participating and benefiting from improved RTB seed (Demo et al. 2015; Mudege et al. 2015).

7. Partnership strategy

FP2 takes advantage of strong established partnerships of participating centers with national and regional research-and-extension programs comprising a network of public and private partners (Table FP2.2). It will extend this further to a broadening circle of advanced research institutes, development agencies, NGOs, policy bodies, and private sector partners. Engaging partners along all levels of the value chain is particularly important to scale up and reach the millions of beneficiaries. RTB will target new strategic partnerships through regional and global stakeholder fora for scaling. Partnerships are key to raising awareness on benefits of using quality seed and improved varieties. Campaign style approaches to give seed away for free often undermine commercial viability and the private sector needs to be the major driver in seed system development, through novel arrangements and attention to incentive structures.

Table FP2.2. Key partnerships for FP2

Partner or player	Role in developing product or achieving outcome
ARIs/Universities	
WUR, KSU, FERA	Seed system framework, degeneration modeling, seed quality control, diagnostic tools, phenotyping
EMBRAPA, BTI, SLU, NRCB, KULeuven, SU, UM, UQ	Breeding, genetics and phenotyping programs, to improve breeding efficiency and develop new varieties
National Agricultural Research and Development agents	
NARS, national plant protection/seed agencies	Participatory variety development and release; provision of breeder seed; evaluating, testing of improved technologies, seed quality control, diagnostic tools
Extension agents, NGOs, dev. agents, private sector, NARS	Dissemination of knowledge and technologies, farmers' organization awareness creation and gender integration during implementation
Government and (sub)-regional organizations	
FARA, ASARECA, CORAF, SADC, R&D networks	Regional coordination of NARS partners and common learning and validation and dissemination of technologies; policy dialogue and development
Policymakers/governments	Support to legal procedures of variety release and seed quality standards
Business organizations	
Private sector	Varietal development, testing, and release; dynamic seed provision (e.g., Kisima Farms, Kenya), aeroponic seed potato provision

Partner or player	Role in developing product or achieving outcome
Small and medium seed entrepreneurs	Production of foundation and certified seed and dissemination of seed of newly released varieties; validation of improved technologies, such as rapid multiplication technologies
Traders and processors	Demand creation for quality planting materials of new varieties
CGIAR CRPs (see also Annex 6)	
Genebanks	Trait identification; use of landraces and CWR held in RTB genebanks; policies and incentives for sharing genetic resources of RTB, benefit-sharing mechanisms
AFS CRPS	Integration and testing of RTB varieties in cereal-based systems, agro-forestry systems
CCAFS	Shared intervention sites, incl. Climate-Smart Villages, for diagnostics and needs assessments and to test RTB technologies within wider portfolios of on-farm interventions; foresight, metrics and models for climate-smart breeding
A4NH	Testing of nutrient-dense RTB varieties in production and food systems; dietary diversity
WLE	Mutual technology validation from a systems and resilience research perspective, technology transfer, shared farm system diagnostics and needs assessments
PIM	Value chain approaches and scaling models for alternative RTB varieties

8. Capacity development

To address the double challenge of low uptake of high-yielding, user-demanded varieties and limited access to quality planting materials, CapDev interventions focus on strategies that cut across public and private sector stakeholders related to the following:

Individual capacities of (1) breeders at NARS, ARIs, and universities to implement conventional and advanced breeding and selection methods, and (2) male and female farmers, processors, and seed multipliers to strengthen both their technical skills (e.g., varietal selection, cultural practices, postharvest techniques, seed production, disease diagnostics and quality control) and their business skills. The wider seed system community of practice will continue to provide a learning forum, and assist in accessing new investments in seed systems.

Gender-sensitive approaches throughout CapDev so that partners co-develop and use participatory gender-sensitive and gender-responsive research methods for the identification of end user preferences, varietal selection, seed interventions, and business models. Barriers that hamper participation of women—for example, to training and field demonstrations—will be addressed to ensure that women can take advantage of the opportunities to develop their skills. Training courses on gender and plant breeding will be jointly implemented with Cornell University.

Developing future research leaders through fellowships for MSc and PhD thesis research and post-docs at universities and technical colleges. Knowledge transfer is also encouraged by practical, hands-on mentorship in well-resourced research laboratories and experiment stations as well as in farmers' fields, and by sponsoring participation in international meetings and workshops.

Design and delivery of innovative learning materials and approaches to reach as broad an audience as possible (e.g., through e-learning training modules on technical protocols, guidelines on best practices and principles, and interactive decision support tools). Education and awareness-raising programs targeting a broad range of stakeholders and channeled through mass media will be used for the promotion of approaches, marketing channels, and strategies for demand creation.

FLAGSHIP PROJECT 3: RESILIENT RTB CROPS

FP3 seeks to close yield gaps of RTB crops arising from biotic and abiotic threats and to develop more resilient and ecologically sustainable production systems, thereby strengthening food security and improving natural resource quality and ecosystem service provision. It will generate outcomes that directly target the needs of women and men smallholder farmers. FP3 comprises seven clusters:

CC3.1 Management of RTB-critical pests and diseases under changing climates, through risk assessment, surveillance, enhanced modeling, and advanced integrated pest management (IPM). Urgent measures are required to tackle the spread of major pest/disease outbreaks in the tropics, which will be further exacerbated by climate change (Smith 2015). In CC3.1, climate models for key RTB pests/diseases will be developed and used to forecast future spread/outbreaks linked to CapDev of national plant protection agencies to respond in an effective and timely manner.

CC3.2 Sustainable RTB crop production systems. Knowledge about abiotic constraints and cropping system factors that limit RTB crop production is currently rudimentary, particularly in Africa where yields are lowest. Yield gap diagnostics across all crops developed in CC3.2 will guide the design of sustainable crop management strategies to address these gaps. Strategies will respond to climate change scenarios for market and household typologies with a focus on gender-transformative opportunities. CC3.2 will link with other clusters in FP2–FP5 to apply these approaches to key hot spots for cropping systems intensification.

BA3.3 Management strategies to reduce losses caused by Fusarium wilt and enhance productivity in banana. Continued spread of Fusarium wilt Tropical Race 4 (FocTR4) poses a global threat to banana production. In addition, the more widespread Races 1 and 2 are causing increasing damage to banana production. BA3.3 will include the identification and deployment of novel sources of resistance, developing and applying new knowledge on pathogen-suppressive soils, as well as strengthening awareness and capacity to deal with Fusarium wilt outbreaks.

BA3.4 Improving the livelihoods of smallholder banana producers in Asia and Africa through recovery and containment of banana bunchy top disease. BBTD, caused by Banana bunchy top virus, is devastating in some of the poorest banana-growing communities in Central, Southern, and West Africa. The disease continues to spread (Kumar et al. 2015), with parts of Asia also severely affected. BA3.4 will develop an integrated suite of measures and CapDev for the exclusion and containment of the spread of BBTD and recovery of banana production in devastated areas.

BA3.5 Regional framework for full recovery of banana production systems affected by BXW in East and Central Africa. BXW is the greatest constraint to the production of banana in East and Central Africa, and threatens to spread further (Tripathi et al. 2009). BA3.5 will extend research on effective management approaches through identifying and deploying novel sources of resistance, improving diagnostics, and expanding the coverage of proven cultural controls such as single diseased stem removal.

CA3.6 Preemptive, emergency, and ongoing response capacity to manage emergent biological constraints for cassava in Asia and the Americas. Climate change and foreign introductions increased pest and disease damage to cassava in Asia (Parsa et al. 2012, 2014). In both Asia and Latin America, commercial forces driving intensification of cassava cropping systems are undermining resilience and making them more vulnerable to large-scale pest/disease attack. CA3.6 will strengthen diagnostics and monitoring, developing pest-suppressive production systems, promoting locally relevant IPM, and building local knowledge and capacity in cassava pest/disease management.

CA3.7 Responses to biological threats to cassava in Africa. CMD and CBSD are the main biotic constraints to cassava production in Africa (Legg et al. 2015). These have been exacerbated through a recent pandemic of unusually severe CMD, and outbreaks of CBSD in areas previously unaffected (Patil et al. 2015). In CA3.7, biological threats to cassava in Africa will be tackled by identifying and deploying both conventional and transgenic sources of resistance, strengthening disease management in seed systems, building intra-continental networks to monitor and respond to disease outbreaks, and enhancing capacity at all levels in understanding and responding to biotic threats to cassava in Africa.

1. Grand challenges

Destructive pests and diseases and abiotic stresses compromise the food security of RTB crop-dependent populations. Several invasive and emerging pests and diseases of RTB crops cause yield losses of 80–100%, with devastating impacts on rural communities. Multiple endemic pests and diseases also drastically restrict attainable yields in all RTB crops and call for smallholder-adapted IPM, congruent with men and women farmers' needs.

Climate change has negative impacts on crop productivity, especially as a result of extreme weather events and increasing pest abundance. Increasing temperatures, rainfall variability, and frequency of extreme weather events (drought, floods) challenge current cropping systems and lead to dangerous geographical shifts and perturbations in pest and disease threats (FAO 2008).

Deforestation and increased intensity of land use are leading to biodiversity loss, soil erosion and landscape degradation, and reductions in critical ecosystem services. RTB crops are produced primarily by smallholders, and cropping environments are frequently sub-optimal. Increased national production often comes from expansion of the planted area and reduced fallow periods rather than from increased productivity or efficient land use.

These challenges demand innovative, geographically extensive yet strongly focused research to deliver products that enable end users to effectively tackle RTB crop production constraints and build resilient and climate-smart cropping systems. This will be achieved through research undertaken by FP3 that links closely with the five other FP of RTB.

2. Strategic relevance and comparative advantage

FP3 will build on the progress achieved in RTB Phase I, notably through research undertaken as part of cross-center projects where the collective skills of multidisciplinary, multi-institutional teams were most effectively harnessed. In addition, RTB is uniquely positioned to develop broadly effective systems of managing critical diseases, because patterns of infection and dissemination are similar for all RTB crops, and solutions developed for a single crop can be readily applied to others.

The RTB-led team of participating centers, research institutes, and national programs in key countries in Asia, Africa, and Latin America has unparalleled expertise in clonally propagated crops for pest and disease characterization and management, and agronomy to respond to the grand challenges to achieve resilient RTB cropping systems.

RTB scientists working in CGIAR played the lead role in the agricultural research intervention that had the single largest economic impact of any CGIAR activity—namely, the classical biological control of the cassava mealybug, which delivered benefits in excess of US $9 billion (Zeddies et al. 2001). These experiences resulted in RTB research teams achieving similar successes even more rapidly in restoring cassava production following the spread of the cassava mealybug to Asia. RTB researchers, working closely with national and international partners, also have a strong recent record of spearheading interventions to understand, monitor, and control pandemics of diseases of cassava and banana in Africa (Tripathi et al. 2009; Blomme et al. 2014; Kumar et al. 2015; Legg et al. 2015). The truly global coverage of RTB is further highlighted by important and geographically extensive pest and disease management initiatives in both Asia and Latin America (Kroschel et al. 2012; Parsa et al. 2012, 2014; Alvarez et al. 2013).

3. Enabling environment and Theory of Change

FP3 places a special focus on the needs of vulnerable, disadvantaged, or disregarded groups, such as the rural poor, women, and youth. FP3 will mobilize improved research tools, capacity building, and impact-oriented research products to contribute to enhanced resilience in RTB cropping systems. This partnership will employ field research teams working at shared pilot sites with other CRPs; modeling; efficient knowledge management systems; as well as the innovative use of information and communication technology (ICT) to introduce more productive and resilient cropping systems in target regions of the tropics. RTB gender specialists will ensure that research products and methods developed under this FP will maximize equity. FP3 proposes key learning platforms on crop and cropping systems, yield gap diagnostics, integrated crop management (ICM), and IPM to maximize dialogue both within and across flagships.

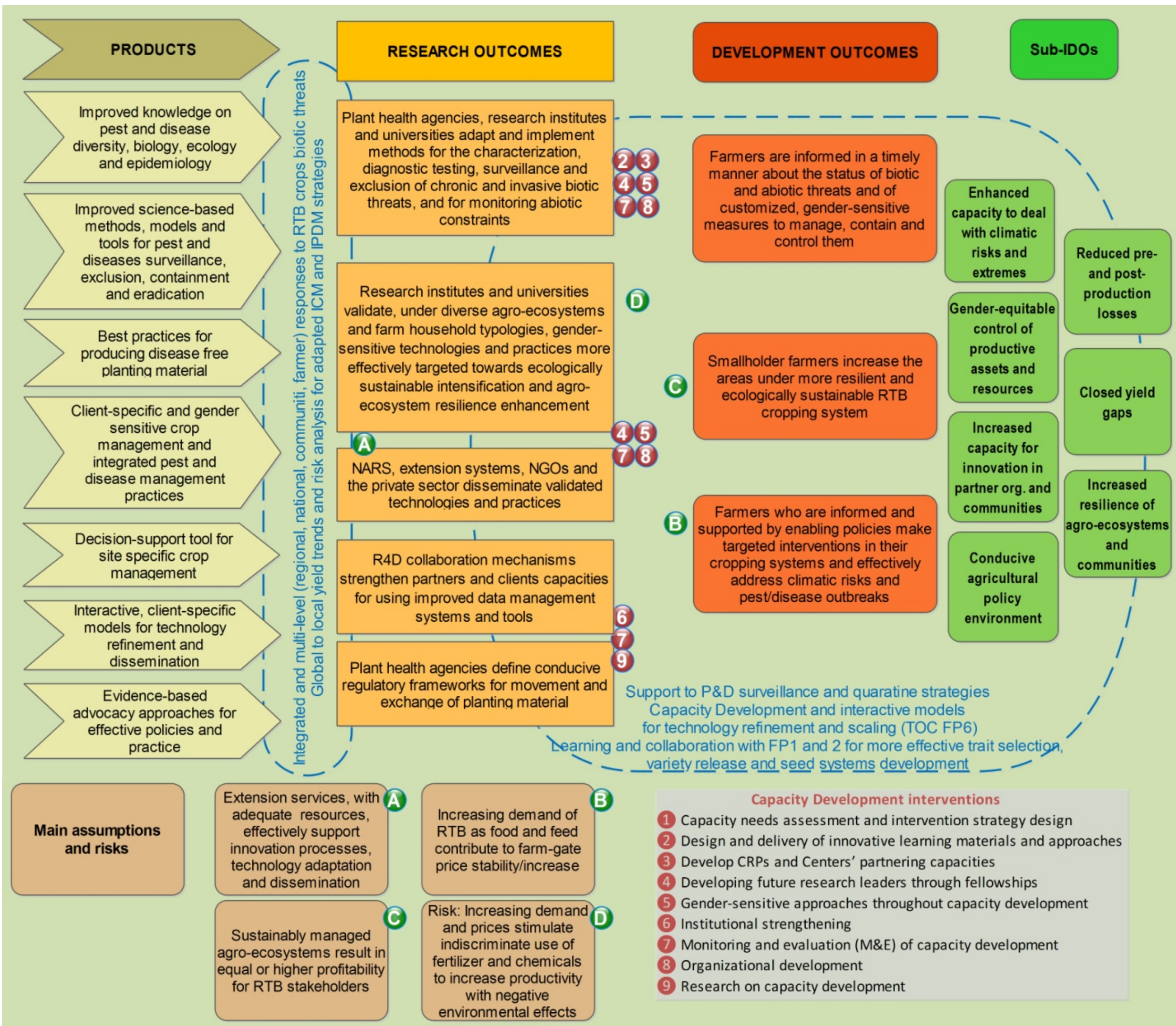


Figure FP3.1. Impact Pathway FP3—main risk/assumptions and capacity development interventions

The impact pathway draws on products from FP2, including candidate varieties of cassava and banana for participatory selection and adaption to user needs in the context of pest and disease management. Linkage with FP5 will guide product development for improved resilience, considering the whole production system. Products from the crosscutting clusters CC3.1, such as pest risk assessments and yield gap diagnosis, will guide and enhance product delivery for resilience and agronomy in crop-specific clusters in FP2 and FP4, and also in a whole-farm context in FP5.

Key risks and assumptions for the logic of the ToC to play through are shown in Figure FP3.1, as well as capacity development interventions.

4. Geography and beneficiaries

Women are often the principal cultivators of RTB crops, and increasingly are involved in pesticide use, with health risks to themselves and their children. There is evidence that women have greater concerns about agriculture-health linkages and are receptive to messages about IPM (Norton et al. 2005). Therefore, women will be specifically addressed with IPM technologies that favor alternative non-chemical means (e.g., biological control). Selected IDOs, geography, and targets for 2022 are presented in Table FP3.1. Annex 1 presents a breakdown of targets by (Sub)-IDO and targets related to crosscutting issues.

Table FP3.1. (Sub)-IDOs, beneficiaries and target countries for FP3

<table>
<tr><th>Target IDOs and Sub-IDOs</th><th>Total number of beneficiaries (2022)</th><th>Target countries</th></tr>
<tr><td>More sustainably managed agro-ecosystem
Increased resilience of agro-ecosystems and communities, especially those including smallholders</td><td>RTB production area converted to sustainable cropping systems
BA3.5: 515,000 ha
CA3.6: 500,000 ha
CA3.7: 1,000,000 ha
New areas infected reduced
BA3.3: Losses of cultivated area (ha) reduced by 20%</td><td rowspan="2">BA3.3
Africa: Mozambique, Tanzania, Malawi, Kenya, South Africa
Asia: Philippines, Indonesia, Papua New Guinea, Malaysia, China, Vietnam, Laos, Thailand
South America and Caribbean: Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Nicaragua, Peru
BA3.4
Africa: Angola, Benin, Burundi, Cameroon, DRC, Central African Republic, Equatorial Guinea, Gabon, Republic of Congo, Malawi, Nigeria, Rwanda, Zambia, Uganda, Tanzania, Ghana, Togo, Zimbabwe
Asia: Philippines, Indonesia, Sri Lanka, Vietnam, Myanmar, Thailand, Papua New Guinea
BA3.5
Africa: Angola, Burundi, Kenya, Rwanda, Tanzania, Uganda
CA3.6
Asia: Cambodia, China, Indonesia, Laos, Philippines, Thailand, Vietnam
Central and South America: Brazil, Colombia, Costa Rica, Nicaragua, Panama, Paraguay, Venezuela
CA3.7
Africa: Angola, Benin, Burundi, Cameroon, Congo, DRC, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Tanzania, Togo, Uganda, Zambia</td></tr>
<tr><td>Increased productivity

Reduced pre- and post-production losses, including those caused by climate change

Closed yield gaps through improved agronomic and animal husbandry practices</td><td>Yield losses reduced at farm HH level
CA3.6: 340,000 HH; 20% reduction in yield losses
Yield restored at farm HH level
BA3.3: 520,000 HH; yield = 80–100% of pre-FOC infection
BA3.4: 380,000 HH; yield = 100% of pre-BBTD infection
BA3.5: 1,000,000 HH; yield = 85% of pre-BXW infection
Yield increased at farm HH level
CA3.7: 1,300,000 HH; 25–30% yield increase

NB. For all clusters, innovative practices are expected to be equally adopted by female and male farmers and at least 25% of the beneficiary households would be female headed (see Annex 1 for more details)</td></tr>
</table>

5. Novelty of science

Novel science common to several of the FP3 clusters includes the use of both conventional and biotechnological techniques to identify and support incorporation of novel pest/disease resistance genes into RTB germplasm in FP1 and FP2; strategic research to elucidate complex interactions between RTB plants in diverse environments impacted by climate change; characterization and modification of the soil microbiome to enhance components that promote productivity while suppressing those that have adverse effects; next-generation diagnostics; application of mobile communication and data-handling systems; and the development of ecologically balanced pest and crop management solutions.

Key areas of novel science and research innovation by cluster are as follows:

CC3.1 Pest/disease management. Novel approaches will be piloted for modeling the phenology and spread of arthropod pests as well as diseases. GIS and climate models will be used to map pest risk, and models will be linked to provide better predictions of crop losses (Kroschel et al. 2013). In order to develop science-based IPM strategies, research will be carried out to evaluate the self-regulating capacity of agro-ecosystems as well as the use of ecosystem services to balance pest problems. Inundative and inoculative strategies for the dissemination of new and existing biological control agents will be investigated. FP3 will look for opportunities to integrate different control agents with other control components, such as the application of bio-rational products and the deployment of host plant resistance.

CC3.2 Crop production systems. Detailed data sets will be generated from a wide range of agro-environments on RTB crop responses to diverse agronomic and ecological factors (variety, nutrients, tillage, intercropping, plant density, weed control, etc.). Key parameters, such as nutrient status at critical stages, soil properties, and meteorological data, will be related to yields to develop expert decision support systems. These systems will use modeling and GIS data to delineate extrapolation domains and fine tune recommendations, enabling farmers to make informed decisions on varietal choice and the most appropriate agronomic measures. Research outputs from this crop-focused cluster will be linked with system-level activities implemented under FP5 through co-location of experimental sites in target countries and agro-ecologies.

BA3.3 Banana fungal disease/Foc. New research under this cluster will tackle Fusarium by improving detection tools for diverse Foc; strengthening mechanisms for epidemiological characterization, surveillance, and monitoring; and developing a diverse array of control strategies. Vital novel information about the behavior of Fusarium species in the plant and soil will be obtained through both classical and metagenomics analyses of soil, root, rhizosphere, and stem micro-organisms (Köberl et al. 2015). These data will be used to guide the development of holistic soil and plant health management techniques. Mass selection techniques will be developed to facilitate screening for resistance.

BA3.4 Banana viral disease/BBTV. Novel research conducted under this cluster will include the characterization and modeling of the epidemiology of the aphid-virus-banana pathosystem, as well as the design of innovative approaches for area-wide, community-based phytosanitary management of BBTD. Virus-vector studies will focus on ecological interactions, vector natural enemies, endosymbionts, and the potential application of transgenic resistance. RTB gender researchers will play a central role in the ground-breaking, community-oriented elements of the disease management work.

BA3.5 Banana bacterial disease/BXW. New applied research will focus on scaling out models for BXW management and beneficiary targeting using socioeconomic analyses. Network analysis and client satisfaction surveys will be used to enhance the coverage of interventions. Although good progress has been achieved in developing diagnostics (Hodgetts et al. 2014), further research will be conducted to provide a comprehensive characterization of the diversity and pathogenicity of *Xanthomonas campestris pv. musacearum* strains and pathovars in both banana and enset cropping systems. This will facilitate the development of more robust and user-friendly diagnostic techniques such as LAMP and lateral flow device. Recently developed BXW-resistant transgenic varieties (Tripathi et al. 2014) will be field tested.

CA3.6 Cassava biological constraints, Asia/Americas. Surveillance and quarantine of rapidly spreading Cassava witches broom (CWB) (Alvarez et al. 2013) will be facilitated through the development and application of low-cost and robust LAMP-based diagnostics. Pest monitoring will be strengthened using crowd-sourcing approaches, remote sensing, volatile-based detection systems, epidemic network modeling, and the extension of pest/disease identification keys. Meta-barcoding and PCR-based elucidation of arthropod food web structure will be applied to improve understanding of pest ecology (Mollot et al. 2014). IPM approaches will be boosted through the innovative use of resistance enhancers, phyto-hormones (for cassava frogskin disease and CWB), or habitat manipulation tactics to enhance in-field abundance and action of key natural enemies.

CA3.7 Cassava biological threats, Africa. Non-invasive phenotyping using spectral imaging technology, as well as LAMP and lateral flow device testing kits, will improve diagnostics and surveillance. Ecological studies will include the manipulation of plant characteristics through breeding to shift tri-trophic interactions in favor of biological control agents for target pests and the development of fungal and bacterial endophytes as "Biohealth" products. RNAi and transgenic techniques will be developed for both pest and virus control, and resistance pyramiding will be used to combine novel conventional sources of resistance with transgenes. In addition to the promotion of clean seed (through linkages with FP2), FP3 will pilot community-based phytosanitation approaches for the area-wide eradication of cassava viruses under contrasting inoculum pressure conditions and develop scaling models for wider application.

6. Previous projects/activities

RTB grant-funded projects that contribute to the aims of resilient cropping systems have been supported throughout RTB Phase I. The project, "Management of RTB-critical pests and diseases under changing climates, through risk assessment, surveillance and modeling," involved all CGIAR centers, ARIs (University of Florida, Aarhus University, CABI, FERA, and Ohio State University), and national research programs in Rwanda and Burundi. A second project, entitled "BBTD containment and recovery: Building capacity and piloting field recovery approaches through a learning alliance," has taken a similar multipartner approach. RTB-funded projects have provided a powerful mechanism for strengthening collaboration between the core partners of RTB. A rich basket of W3/bilateral projects has made significant progress in tackling some of the key R4D issues of relevance to resilient cropping systems (Table FP3.2). The suite of these projects that are part of RTB is strongly congruent with the set of clusters of FP3. The RTB-RBM pilot work on the BXW cluster (BA3.5) and recent BXW research have proven to be an excellent investment, as several highly effective management approaches have been developed; others are in the pipeline (Blomme et al. 2014). FP3 members will be encouraged to further strengthen the portfolio of W3 and bilateral projects contributing to the flagship, and this is anticipated to expand in RTB II.

Table FP3.2. Selected W3 and bilateral projects contributing to the goals of resilient RTB cropping systems

Donor	Title	Description
FONTAGRO	Strengthening smallholder organic export banana in Latin America and the Caribbean: Agro-ecological management of pests and soils and within sector linkages	Building banana smallholder capacity for agro-ecological intensification in LAC
McKNIGHT FOUNDATION	Integrated management of Xanthomonas wilt of bananas in smallholder systems in East and Horn of Africa	Reducing spread and strengthening control of BXW within East and Central Africa

Donor	Title	Description
PHILIPPINES	Mitigating banana Fusarium wilt Tropical Race 4 through a farmer-participatory approach of developing disease management strategies	Reducing spread and enhancing control of Fusarium banana wilt (Foc) within the Philippines and the wider region
BMGF	Virus Resistant Bananas for Africa	Development of transgenic resistances in accepted banana cultivars to banana bunchy top and banana aphid, the vector of BBTV
BMGF	Community Action in Cassava Brown Streak Disease Control through Clean Seed	Pilot-level development of community-based approaches to control cassava virus diseases in Tanzania
BMZ	Predicting climate change induced vulnerability of African agricultural systems to major insect pests through advanced insect phenology modeling, and decision aid development for adaptation planning	Development and application of models, such as insect life cycle modelling, to enhance the forecasting and management of climate-change–induced effects on insect pests
BMZ	Development and implementation of a sustainable IPM and surveillance program for the invasive tomato leafminer, *Tuta absoluta* (Meyrick), in North and sub-Saharan Africa	Reducing the spread through better predictions of its potential range expansion, and the development and use of biological and bio-rational control

7. Partnership strategy

FP3 will be implemented through a global partnership of research institutes, plant protection organizations, and extension systems (Table FP3.3). These will draw on specific expertise from developed country partners where this adds value and contributes to strengthening capacity. Linkages will be developed with the private sector (including partners such as tissue culture labs, biocontrol companies, and agro-input suppliers).

Table FP3.3. Key partnerships for FP3

Partner or player	Role in developing product or achieving outcome
Strategic research partners	
Fera Science Ltd (UK)	Pest risk analysis; certification and quality declared seed; diagnostic development and validation; proficiency testing schemes
University of Florida	Development of pest/disease models and of modeling platforms
UCLA	Climate change risk modelling, genomics, biodiversity
Plant protection organizations	
CABI – Plantwise	For innovative surveillance (through extension including mobile plant clinics and going public exercises) and for knowledge-based information exchange including the development of disease distribution maps
IPPC-FAO, EPPO, IAPSC	Pest risk assessment, and regulatory mechanisms and protocols
AGDP, FAO	Surveillance methods and networks and government policy guidance
Regional and sub-regional organizations	
ASARECA, CCARDESA, CORAF, IICA	Priority setting, policy and capacity development
National research systems (NARS)	
Asia: Guandong Academy of Agriculture, Yunnan Academy of Agriculture, Australia Queensland DAFF, Indonesia ITFRI, IPB,	Research on pest and disease modeling and management, support for quality seed production

Partner or player	Role in developing product or achieving outcome
Philippines UPLB, PCCARD, India NRCB, Vietnam FAVRI, VAAS, Thailand, DoA, KU, DoAE	and linkages with extension, and community-based phytosanitary systems
East and South Africa:, KALRO, NARO, DRD, INERA, ISABU, RAB, Makerere U., UNIKIS, UNIKIN, DARS, ZARI, Stellenbosch U., UDSM, Sokoine U., IIAM, EARI, Juba U.	As above
West and Central Africa:, Nihort, CARBAP, CERAL, IRAF, INRAB, UAK, CRI, CNRA, NRCRI, Dschang, Yaounde	As above
Latin America: Dominican Republic IDIAF, Nicaragua UNAN – Leon, Colombia CORPOICA, INIA Peru, Brazil Embrapa, Costa Rica Corbana, CATIE, Cuba INISAV, INIAP Ecuador, PROINPA Bolivia	As above
CGIAR CRPs (see also Annex 6)	
WLE FTA	Integrate research approaches Identify and work in shared target regions for enhanced efficiency
CCAFS	Joint research on modelling climate change effects on pests and diseases and on adaptation in technology testing at Climate Smart Villages

8. Capacity development

FP3 aims to enable end users to effectively tackle RTB crop production constraints and build resilient and climate-robust cropping systems. A specific objective is to strengthen R4D capacity to support resilient RTB cropping systems. To achieve this objective, the flagship will link up strongly with FP5, as well as FP6 (CC6.1: knowledge, capacities, partnerships) and focus mainly on three types of CapDev interventions:

Institutional strengthening through advocacy approaches for effective policies and practice that strengthen capacities of partners and clients for (1) using improved data management systems and tools, and (2) defining conducive regulatory frameworks for movement and exchange of planting material.

Organizational development through the establishment of learning platforms on ICM and IPM. CapDev efforts targeting plant health agencies, research institutes, and universities will enhance their capacity to (1) adapt and implement methods for the characterization, diagnostic testing, surveillance, and exclusion of chronic and invasive biotic threats, and to monitor abiotic constraints; and (2) validate, under diverse agro-ecosystems and farm household typologies, gender-sensitive technologies and practices more effectively targeted toward ecologically sustainable intensification and agroecosystem resilience enhancement. NARS, extension systems, NGOs, and the private sector will therefore be empowered to share validated technologies and practices with smallholder farmers.

Capacity development and gender. CapDev will ensure that research institutes and universities acquire the knowledge, attitudes, and skills to recognize and integrate gender-sensitive approaches in designing and practicing crop and integrated pest and disease management. All capacity-building efforts will actively empower women at national and regional levels within regulatory, research, and extension systems through training and workshops to ensure at least 30% female participation. Mentoring opportunities will be availed to women scientists. Extension activities will recognize that it is women who often manage RTB crops and often control the revenue generated. The development and distribution of media and materials for sensitization will take gender preferences into account.

FLAGSHIP PROJECT 4: NUTRITIOUS FOOD AND VALUE ADDED THROUGH POSTHARVEST INNOVATION

FP4 aims to harness the nutritional potential of RTB crops more widely and expand their utilization and add value through postharvest innovation. FP4 comprises four clusters:

CC4.1 Demand-led approaches to drive postharvest innovation and nutrition improvements. Will accelerate RTB postharvest innovation and nutrition improvement by integrating technology and social and economic research. The cluster will determine and enhance how and where RTB crops can best contribute to nutrition outcomes within a wider food environment and livelihood context (Herforth et al. 2015). It learns from and provides support to crop clusters inside FP4 and enables effective linkages with postharvest and nutrition related research in FP2, FP3, and FP5.

CA4.2 Raising incomes and improving the health and safety at small and medium cassava processing centers, preferentially for women and youth in rural and urban areas. CA4.2 focuses on improving processing technology, health and safety, environmental and energy efficiency, as well as supply chains and market performance, utilizing preferred varieties developed in FP2 and supported through FP3.

CA4.3 Biofortified cassava varieties for improved nutrition and livelihoods and **SW4.4 Nutritious sweetpotato in expanding markets and improved diets.** These two clusters provide the products and enabling framework, including evidence for advocacy and supportive value chains, to realize nutritional and increased income outcomes from biofortified cassava and sweetpotato at scale. They are closely linked with FP2 by setting end user priorities for nutrition and market related traits of candidate varieties.

1. Grand challenges

Persistent rural malnutrition, especially undernutrition. The number of undernourished people in Africa is increasing and the world is not on course to meet global nutrition targets (FAO 2015; IFPRI 2014). Women of reproductive age and young children are most vulnerable to undernutrition because of their increased nutritional needs and social marginalization. Micronutrient deficiencies can have fundamental and irreversible impacts on physical and mental development of children. Through R&D, along with processing and postharvest management to extend availability, RTB crops can reduce undernutrition amongst millions of vulnerable consumers.

Feeding rapidly growing urban populations. As of 2014, 54% of the global population lives in cities, and 66% is projected by 2050. Supplying nutritious and affordable staple foods for these populations will require a reorientation of agri-food systems in many low-income countries. RTB crops can be grown comparatively easily in large quantities in many countries that are over-dependent on imported grains. FP4 will harness the relatively untapped potential for improving processing and reducing postharvest losses of RTB crops. Such gains should help to reverse the trend of declining RTB consumption among urbanizing populations due to the crops' perishability and bulkiness.

Climate change. The IPCC (2014) forecasts negative impacts from climate change on food and nutrition security by the mid-21st century. FP4 will contribute to improved strategies for ensuring food and nutrition security in vulnerable countries, utilizing a range of nutritious and resilient RTB crops that offer comparative advantages.

Diets are becoming less diverse, healthy, and nutritious. The number of people overweight or obese is growing fast globally and leading to an estimated loss of 35.8 million disability-adjusted life years and rising diabetes rates. By 2035, diabetes is projected to affect more than 500 million people, the vast majority in low- and middle-income countries and affecting women more acutely than men. RTB crops are mainly recognized as a source of calories stored as starch, thus contributing to the problem of obesity and diabetes. But they are also potentially functional foods that provide fiber and other key elements in more diversified diets. Recent research in cassava suggests that RTB varieties with resistant (high-amylose, low-glycemic) starches can be developed as healthier and economically valuable alternatives. Linking this research with nutrition education and behavior change interventions, FP4 can make new and significant contributions to managing the public health risks of obesity and diabetes.

Postharvest losses are often high for RTB crops and food safety is a growing concern. Managing the perishability of RTB crops and meeting increasingly differentiated market and policy demands are major challenges. FP4 will strive to enable producers and processors to meet food safety and quality standards, through research on nutrition qualities, sensory attributes, contamination, and convenience and packaging of fresh produce and processed products. FP4 will strengthen the demand-orientation of the whole RTB program and link with consumer education and policy advocacy to expand demand for nutritious and safe RTB crops and products.

New entrepreneurial and job opportunities are emerging from changing patterns of agri-food demand. These can provide spectacular growth opportunities for RTB crops with cassava in West Africa at the forefront (The Economist 2015), and other crops such as potato and sweetpotato expanding into new urban markets. Whilst local agri-processing generates large amounts of employment for rural youth and women, improved technology is needed to improve efficiency and safety.

Environmental pollution and energy losses. Inefficient use of energy, water, and other inputs, process wastes, and sub-optimal use of by-products of RTB crops lead to environmental impacts and reduces competitiveness of the processing industry. As observed by UNEP (2007), this issue has gender ramifications as well: “Women and girls often carry a disproportionate burden from environmental degradation compared to men.” Improving efficiency and utilizing by-products is an expanding area of RTB research.

2. Strategic relevance and comparative advantage

FP4 draws on progress, knowledge, and competencies in RTB to utilize sweetpotato, cassava, banana, potato, and yam to support healthy and diversified diets. Biofortification is under way for most RTB crops, at different stages of R&D. Vitamin A-rich OFSP is well advanced in more than 10 African countries and expanding to others in Africa and Asia where demand is high. Vitamin A biofortification of cassava is advancing fast, with wide-scale distribution in Nigeria; banana and yam are at earlier stages of development. Breeding for cassava, potato, and sweetpotato, biofortified for iron and zinc, is underway. Iron-fortified potato could be available within two years, and iron-fortified OFSP within five years is possible, if desired investment levels are obtained.

FP4 recognizes that gender is a key element in the linkage between nutrition and agriculture, and that gender roles for RTB crops often offer greater opportunities for women. FP4 will investigate the social determinants of behavior change in order to effectively support both women and men to realize benefits from postharvest innovation and nutrition improvement of RTB crops.

CIRAD plays a vital role in FP4, bringing strong capacity for assessment of nutritional impact of processing (nutrient loss, detoxification, increased bioavailability, etc.), consumer preference, and expertise in local processing, downscaling technology for use by small enterprises and life-cycle analysis.

The network of partners established by RTB is in a unique position to implement FP4 successfully: (1) processing and market development research will complement genetic improvements and provide a strong demand pull for traits that are preferred by diverse end users and clients; (2) particular attention will be paid to gender equity, as well as issues of storage, transportability, and gaining market share through processing into diverse products for faster adoption; (3) process engineering tools, including multi-objective optimization and life-cycle assessment, and the integration of technical, economic, and environmental aspects into the design of improved RTB processing techniques; and (4) RTB scientists have a strong background in pro-poor value chain approaches that will be leveraged (Devaux et al. 2009).

Improved RTB-based products can be a success only if they are adopted by consumers. RTB scientists are already advanced in sensory analysis and consumer preferences studies to ensure that the improved products meet the expectations of consumers. Analyses and studies take into account differences between the preferences of men, women, and children from different socioeconomic groups.

Unintended consequences. Promotion of biofortified varieties, such as OFSP and yellow cassava, inevitably focuses attention on specific nutrients and new varieties as vehicles for supplying these nutrients. RTB will integrate these interventions with FP5 to ensure that they are designed, implemented, and evaluated in a holistic nutrition context (a "food basket" approach). When creating demand for processed products such as urban snacks or bakery goods, however, there is a risk of promoting increased consumption of fats, salt, and refined sugars. FP4 will build capacity for promoting healthy food choices along the whole value chain.

Especially in Africa, small-scale processing of cassava and other crops is in the hands of women and contributes to their livelihoods. Mechanization of gari, for example, may reduce drudgery and increase efficiency of conversion; but it also may shift control into men's hands and undermine women's livelihoods. FP4 will pay close attention to trade-offs of productivity and gender equity to mitigate this risk.

Additionally, postharvest processing of RTB crops generates significant quantities of by-products (e.g., peels, fiber bagasse, wastewater), which typically accumulate on limited area around the processing site(s) and/or pollute local water systems (Tran et al. 2015). Expansion of postharvest technologies must include appropriate strategies for process efficiency and management of by-products. Better utilization of by-products for non-food purposes (animal feed, fuels, fibers, fertilizer) is an opportunity to mitigate competing demands for the main RTB crop raw materials, and to balance income generation with equity and well-being, so that the rural and urban poor—especially women (producers or processors)—can participate and benefit fairly in these expanding value chains.

3. Enabling environment and Theory of Change

The impact pathway of FP4 (Fig. FP4.1) comprises products that generate research outcomes with next users. Outcome support will contribute to making affordable, nutritious food available for many millions of the world's malnourished people and will spur processing and postharvest innovation to expand production and consumption of RTB crops and add value in order to reduce poverty. The impact pathway draws on products from FP2–FP4, including candidate varieties of cassava and sweetpotato for participatory selection and adaption to user needs. FP5 provides a livelihood context and space to take a more holistic food basket approach that combines different nutritious RTB foods and others. Work on other micronutrient-rich varieties is included in the productive varieties flagship (FP2), with CC4.1 linking this work together across the portfolio. Products from CC4.1, such as protocols for postharvest loss reduction and consumer acceptance of preferred quality traits, will guide and enhance FP2. As a cluster moves to scale, the balance of research and outcome support shifts. Scaling of sweetpotato is well advanced, thus providing learning opportunities for other crops.

Figure FP4.1 shows the key risks and assumptions for the logic of the ToC to play through, as well as CapDev interventions.

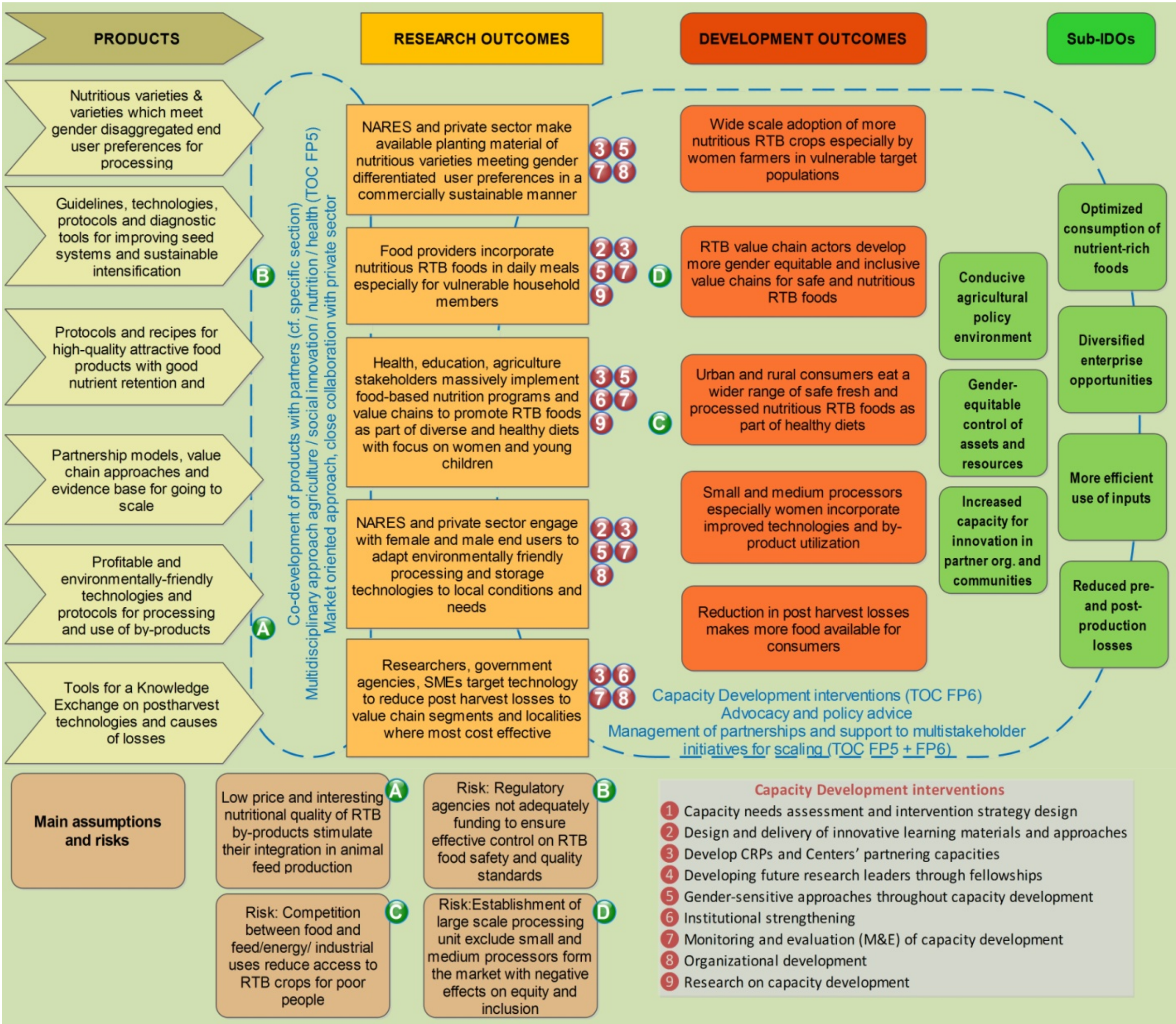


Figure FP4.1. Impact Pathway FP4–main risks/assumptions and capacity development interventions

4. Geography and beneficiaries

Geographical and beneficiary targeting of FP4 is guided by (1) the need and demand for nutritious RTB food arising from undernutrition and from specific micronutrient deficiencies, especially of the most vulnerable such as pregnant and lactating women and children under two years; (2) existing or potential market demand for RTB processing that can create income and livelihood opportunities for the poor and women and youth especially; and (3) the feasibility of specific nutritious RTB crops to contribute to solving these challenges in different locations. Selected IDOs with quantified targets for 2022 are presented in Table FP4.1. Breakdown of targets by Sub-IDO and targets related to crosscutting issues can be found in Annex 1.

Table FP4.1. (Sub)-IDOs, beneficiaries, and target countries for FP4

Target IDOs and *Sub-IDOs*	Total number of beneficiaries (2022)	Target countries
Improved diets for poor and vulnerable people *Optimized consumption of diverse nutrient-rich foods*	Dietary diversity score (DDS) increased **CA4.3**: 20% increase in DDS; 1,400,000 HH **SW4.4**: 20% increase in DDS; 2,000,000 HH *NB: All households members and particularly children under 5 years, women of reproductive age, and the vulnerable* Consumption of vitamin A-rich foods increased **CA4.3**: 50% of children under 5 years of age consume vitamin A-rich foods at least twice in a week; 1,200,000 HH **SW4.4**: 50% of children under 5 years of age consume vitamin A-rich foods at least twice in a week; 2,000,000 HH **CA4.3**: 50% of women of reproductive age; 30% increase in intake of vitamin A-rich foods; 1,000,000 HH **SW4.4**: 50% of women of reproductive age; 40% increase in intake of vitamin A-rich foods; 2,000,000 HH Risks associated with unsanitary and poorly processed cassava reduced **CA4.2**: 2,600,000 consumers	**CA4.2** **Africa:** Benin, Cameroon, Ghana, Nigeria, Tanzania, Uganda **Americas:** Brazil, Colombia **Asia and Pacific:** India, Indonesia, Malaysia, Philippines **CA4.3** **Africa:** Angola, Benin, Cameroon, Congo, Côte d'Ivoire, DCR, Gabon, Ghana, Kenya, Liberia, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Tanzania, Uganda, Zambia **Americas:** Brazil, Colombia, Haiti, Guatemala **Asia:** Indonesia, Philippines **SW4.4** **Africa:** Angola, Benin, Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda, Zambia **Asia:** Bangladesh, India, Indonesia, Papua New Guinea **Caribbean:** Haiti
Increased incomes and employment *Diversified enterprise opportunities* *More efficient use of inputs*	Annual household revenue improved through increased and diversified sales (food, feed, industrial raw material and seeds **CA4.3**: 2,000,000 people; 20% revenue increase **SW4.4**: 1,500,000 people; 15% revenue increase Production cost reduced **CA4.2**: 20,000 small- and medium-scale processors; 15–20% energy and water savings	

5. Novelty of science

CC4.1 Postharvest innovation and nutrition improvement. Includes: (1) research on scientific methods and engineering tools to scale down current technologies and to better manage by-products and waste, while preserving the benefits of economies of scale; (2) methods of sensory analysis and end users' preferences assessments to the specificities of RTB-based products produced at small and medium scale in developing countries; (3) models for strengthening food quality and safety in fresh RTB produce markets, while safeguarding access for poor producers and consumers; (4) improved indicators for measuring diet quality (beyond diet diversity) and the contributions of increased consumption of nutritious RTB foods and other nutritious non-staple foods. Systematic evaluation of commercial and subsidized approaches to scaling up nutritious RTB foods will measure differential flows of benefits to vulnerable target populations (including assessment of gender and poverty outcomes). This will guide methodologies for measuring (cost) effectiveness of different scaling-up approaches in terms of achieving nutrition goals.

CA4.2 Cassava processing. Although cassava processing is trending toward larger-scale factories throughout South-east Asia, many small and medium enterprises (SME) remain. Here, as in SSA where SME predominate their continued viability, important for local livelihood systems, will depend in part on the adaptation of greater processing efficiencies. Markets are dynamic and the processing needs to be adaptable to starch, diversified food products, and animal feed. Engineering methods for process modeling, including technical, economic, and environmental parameters will be adapted to small- and medium-scale cassava processing operations, in particular drying, grating (rasping), and pressing. Recommended practices for the production of clean planting material and agronomic practices will be tested and adapted for best performance according to local conditions in selected countries. *Change of scale*: Design and test at pilot scale a stable wastewater-to-biogas system, adapted to cassava processing at small and medium scale, based on the efficient large-scale systems in use at cassava starch factories in Thailand. *Novel uses*: To develop processing technologies to increase the value and use of by-products in the cassava value chain (e.g., co-development of cassava processing and animal farming, using peels and fibers by-product as raw materials to produce animal feed).

CA4.3 Biofortified cassava. Together with CA2.3, consumer studies will enhance knowledge of preferences for tuber shape; plant architecture; and a range of flavor, texture, appearance, and many criteria for acceptability. In collaboration with CA4.2, Pro vitamin A cassava-based new recipes will be tested with partners, and sensory evaluation and market acceptability tests will be carried out. Biochemical tools will be developed to access storability and retention.

SW4.4 Nutritious sweetpotato. Value chain-demanded attributes (e.g., consumer quality attributes, reduced perishability, production attributes, etc.) will be linked to genomic approaches to applied breeding in FP2. Action research will better integrate existing agro-enterprises into the OFSP value chain, including fresh produce and input markets and affordable techniques for fresh root storage and handling. Research to understand nutrition outcomes of food basket approaches anchored in OFSP will promote complementary nutritious foods and healthy diets. Research to assess incentives for OFSP adoption and utilization will guide different scaling approaches and partnerships, including agriculture, market, and health sector-led approaches. Concerted approaches to advocacy, demand creation, and capacity development along the value chain will enable scaling up.

6. Previous projects/activities

FP4 builds on a strong foundation from RTB Phase I and, in particular, the success of OFSP with multiple projects going to scale. For instance, under the BMGF Sweetpotato Action for Security and Health in Africa project, based on rigorous evidence from efficacy and effectiveness research, OFSP was adopted by more than 1.1 million households in Africa over the past five years. The project demonstrates how a nutrition-focused agricultural innovation can significantly improve diet quality and rural livelihoods (Hotz et al. 2012). Important, scalable achievements from this work include models and methodologies for effective research design, sequencing, and coordination that integrate nutrition/behavior change and postharvest/market interventions with continued research on crop improvement, seed systems, and production systems.

More recently, biofortified yellow cassava has made significant progress in scaling in Nigeria. Lessons and achievements from both crops will be scaled out to new generations of biofortified RTB varieties to realize faster and wider impacts on nutrition of millions of households that depend on RTB.

In an RTB-funded project (2013–2015) in Benin and Cameroon, sensory analysis and end users' preferences studies of gari and fufu provided information on the key criteria used by consumers to adopt or reject these products, which helps to increase the rates of adoption of improved products. The methodological approach for sensory analysis and end users' preferences can be replicated for other RTB-based products and other countries.

A cross-continent RTB-funded project to improve cassava processing systems developed models to down-scale and transfer the efficiencies of large starch driers to small scale, especially for Africa (Chapuis et al. 2015; Hansupalak 2015). In West Africa, RTB collaborated with CRPs Livestock and Fish and Humidtropics to develop innovative processing and drying of cassava peels for animal feed, potentially removing up to 14 million t of peels from the waste stream in Nigeria alone, and adding value to the feed value chain (Okike et al. 2015).

7. Partnership strategy

Several criteria are applied for identifying (research) partners and building up networks and agreements (Table FP4.2):

- Complementary skills and capacities
- Large "like-minded" strategic partners with whom to go to scale in several countries
- Testing of several partnership models at each scaling-up stage, seeking to improve RTB capacity for partnering, both technically and administratively
- Linkages with mainstream initiatives and institutions in other sectors such as vocational training institutions, youth employment and rural entrepreneurship programs, and national nutrition education programs
- Engagement of private sector partners as drivers of change and value chain segments where longer term capture of benefits by small-scale producers with gender equity can occur.

Table FP4.2. Key partnerships for FP4

Partner or player	Role in developing product or achieving outcome
ARI/Universities	
Natural Resources Institute (NRI), UK	Storage systems and postharvest management practices; value chain analysis; modeling processing systems and efficiency of processing plants
Biosciences East/Central Africa; BecA-ILRI Hub	Hosting researchers; linking NARS through Africa Biosciences Challenge Fund; capacity building and research placements in nutrition and food safety analysis
National Research institutes (NARES)	
NARS (NRCRI & INERA)	Participatory evaluation, varietal release, production of breeder seed, evaluating and testing of improved processing technologies, soil fertility, and crop management
NSTDA – BIOTEC	New product development (starch, flour); utilization of by-products; quality control methods. EcoWaste: Process engineering; up- or down-scaling of unit operations; wastewater management (biogas)
CSTRU	New product development
Private sector	
Food technology firms Euro Ingredients Ltd	Product development, food safety standards, and procurement and installation of equipment. Capacity strengthening of private industry.
Small and medium seed entrepreneurs	Quality seeds of newly released biofortified clones, reaching farmers and end users
Machinery manufacturers and fabricators	Development of prototype machinery; better adapted to workers' welfare; equipment that incorporates women's preferences and needs
Private sector: SMEs and cooperatives	Business analysis and feasibility studies for new plants and plant renovations; capacity to evaluate end-user preferences; production and marketing of intermediary products (e.g., sweetpotato puree)
Commercial processors	Product development and marketing; consumer studies; labeling and consumer education; monitoring of market performance of processed RTB products
Development organizations/associations	
NGOs (e.g., Concern Worldwide)	Mainstreaming RTB biofortified varieties into food security and nutrition programming, distribution of planting materials, farmer training, and monitoring
CRS, Concern	Planting material and promote the use of PVA cassava. Gender sensitivity training; gender-appropriate data collection tools; understanding women's roles in processing. Equitable credit environment, especially for women.

Partner or player	Role in developing product or achieving outcome
	Concern: Linkages with civil society groups in SUN movement.
PATH	Linkages to infant and young child-feeding and health services
Women's processor associations	Participatory design and evaluation of processing technology; feedback on product characteristics; feedback on constraints for access to markets
Farmer groups/ associations, lead farmers	Testing production technology to supply better product and more consistent supply to the processors; market intelligence; accelerated release of preferred varieties
Cassava growers associations	Participatory variety development; policy advocacy
CGIAR CRPs (see also Annex 6)	
A4NH	Lead: nutritional efficacy and bioavailability studies, nutrition evidence, standards for biofortified products, food safety, and health benefits. Collaborate: value chain delivery, processing, assessments of effectiveness. RTB emphasizing crop-specific and RTB-specific perspectives.
WLE Livestock	Cassava waste and water management, and feed utilization with waste and sweetpotato foliage

8. Capacity development

FP4 will train, strengthen capacity, and learn with multiple partners, including women's agency experts of RTB value chains. The key intervention points for CapDev in the impact pathway are shown in Figure FP4.1.

Organizational development and institutional strengthening. The main CapDev focus will be to enhance NARS research capacity and strengthen boundary partners for research uptake. Examples are the mainstreaming of biofortification of RTB crops into national breeding programs, improvement of national seed systems, and enhancement of NARS and private sector's capacity to engage with end users to adapt environmentally friendly processing and storage technologies. Public-private partnerships along the value chain provide entry points CapDev research, such as the question on how to develop concerted approaches to advocacy, demand creation, and capacity development along the value chain to enable scaling.

Partnership models, value chain approaches, and a strong evidence base from FP research will strengthen institutional capacity for going to scale. The intent is for health, education, and agriculture stakeholders to implement food-based nutrition programs and value chains focusing on women and young children.

Design and delivery of innovative learning materials and approaches. RTB will make use of opportunities for targeted CapDev (e.g., at small- to medium-scale cassava processors, specifically women and youth in rural and urban areas). For example, it will roll out for adaptation by lead national training institutes the multimodule training-of-trainers course on "Everything you ever wanted to know about sweetpotato." It will promote recipes for nutritious and diverse food products for food vendors, processors, and homes, while increasing partnership capacity with food technology firms and the private industry.

Gender and youth-sensitive approaches will be developed and applied throughout all CapDev interventions in RTB. Attention will be given to gender sensitivity training in partnership with NGOs, women associations, and the like. There is a special opportunity to develop and strengthen the capacity of boys and girls to develop as entrepreneurs for small businesses along the postharvest value chain through, e.g. the integration of key messages into school curricula as well as investment in education and trade schools.

FLAGSHIP PROJECT 5: INTEGRATED SYSTEMS FOR IMPROVED LIVELIHOODS

FP5 aims to enhance capacities to innovate in RTB-based agri-food-systems, while ensuring improved gender equity and youth participation. FP5 will develop tools and approaches that (1) improve identification and prioritization of problems and opportunities, (2) encourage investment, (3) enable participatory testing of RTB intensification options (drawn from FP1–FP4) for innovation in a livelihood context, (4) stimulate diversification and social interventions within the larger systems context, and (5) promote learning for better impact (with FP6). The flagship comprises two crosscutting clusters (CC) that guide work in the four place-based (PB) integrative clusters:

CC5.1 Sustainable intensification and diversification (SID). This cluster supports innovations that increase "whole-farm productivity" while improving resilience, income, nutrition, and natural resource integrity functions at household and landscape levels. Tools will be developed and applied with stakeholders in the PB clusters to (1) understand diversity in needs and response options and (2) analyze trade-offs/synergies across diverse farm activities, objectives, and scales.

CC5.2 Institutional innovations, decision-support, and youth employment. This cluster designs, develops, and pilots institutional and decision-support innovations (including ICT) that enhance technology adoption at individual and community levels, while facilitating more diverse participation of youth in the agro-food value chain system, both upstream (production) and downstream (agro-processing and marketing).

PB5.3-PB5.6 clusters provide space for innovative partnerships to jointly design and test systems innovations for livelihood improvement that are context-specific and "home-owned." FP5 draws on and supports FP1–FP4 to align research products with innovation demand in a livelihood systems context.

PB5.3 East and Central Africa: Mixed RTB crop-tree-livestock farming systems by smallholders. Banana, cassava, sweetpotato and potato are staples and cash crops, complemented by beans, maize, grain legumes, sorghum, groundnut, minor leafy greens, and other vegetables. Small farm sizes (<2ha) and over-exploitation of the natural resource base cause low crop yields and malnutrition.

PB5.4 West Africa lowlands: Mixed RTB-tree-crops systems. Plantain, cassava, yam, and sweetpotato are staples with increasing urban/industry market pull and opportunities for women and youth.

PB5.5 Central Mekong: Includes diverse farming systems with a substantial RTB crop component. Strong market pull in economic growth areas, triggers unsustainable crop intensification with adverse environmental impact, whereas more remote areas struggle with limited and unequal access to market and low and decreasing productivity resulting in low total farm income.

PB5.6 Tropical Americas and Caribbean: In the Andes, crops vary along an altitudinal gradient, potato at higher altitudes, and banana, cassava and sweetpotato at mid and low elevations, intercropping with barley, maize, and vegetables is complemented by mixed livestock systems. Whilst in the Caribbean, root crops and banana are important, often with tree crops. 75% of the land is degraded by erosion and nutrient depletion.

1. Grand challenges

RTB crops contribute to food and income security of 200 million smallholders, often in mixed systems with tree crops, (small) livestock, and other on- and off-farm activities. Smallholders are inherent systems managers, but research is often still compartmentalized, leading to a mismatch between research supply and end user needs. Smallholder men and women operate in a policy and institutional environment that affect their investment opportunities. Understanding actor interdependency is required to enable improved decision-making. There are four grand challenges that underpin the work in this flagship:

Income shocks and nutritional insecurity may increase for vulnerable smallholders when focusing resources investments into fewer "specialized" businesses at a time of climate change. Value chain approaches can provide income-generating opportunities but may discourage diversity of inter-connected components in mixed RTB-based farming systems, thereby threatening "whole-diet" diversity, income security, crop biodiversity, soil fertility, and farm-level productivity. The risks for food/income shocks when specializing are particularly high for women and marginalized groups who have fewer resources to cope with climate change, unexpected market behavior, or pest-induced yield shocks.

New entrepreneurial and job opportunities are emerging and maintaining an interest by youth is essential. Many options for sustainable intensification of RTB systems require additional agricultural labor, which is often not available both in terms of quantity and quality. As well, there is a reservoir of youth (sometimes with high education) who do not see a future in agricultural production and prefer to move to the cities and look for jobs that are often too few and thus highly sought after. This poses immediate constraints to agricultural development, and threatens longer term food security. Without new generations of skilled farmers and agri-business entrepreneurs, developing countries will become more dependent on costly food imports from ever more efficient and competitive farmers in developed countries. Insufficient economic perspectives for youth can also be a threat to the political stability of countries.

Soil degradation on land already farmed is a critical constraint. Population growth reduces farm size and accelerates nutrient extraction, degrading natural resources and ecosystems services. Agricultural production increments in developing countries have often originated from area expansion rather than yield increments. Natural and fallow lands are steadily decreasing and degrading, negatively affecting ecological services (e.g., soil, water). Social-cultural norms further negatively impact women, who have smaller land, less fertile land, and less fallow land (Doss 2001). When intensification occurs in response to new (industrial) market opportunities, farmers are not always sufficiently equipped or encouraged to use climate-smart integrated crop and soil management practices.

Climate change creates an array of challenges for RTB livelihood systems. Many of these challenges are addressed in FP1–FP4. FP5 looks at the entire system to improve resilience and build knowledge and capacity to adapt to climate change.

2. Strategic relevance and comparative advantage

A collaborative partnership among the RTB participating centers with other CGIAR centers (ICRAF, ILRI), non-CGIAR research partners (WUR, AVRDC, FARA), and national and regional partners in the PB clusters form the heart of this flagship. WUR brings in key expertise on social science and institutional innovation, including the (potential) role of ICT, as well as on farming systems analysis and trade-off modeling. FARA serves as the technical arm of the Africa Union Commission and is already in partnership with WUR and NARS in R4D on ICT and agricultural innovation. FARA will play a role in aligning and embedding institutional innovation with national and regional public bodies.

FP5 builda on key lessons learned from RTB and Humidtropics. The livelihood systems approach looks at all components of the system in an integrated manner rather than the individual parts. It provides guidance to the other flagships in RTB in terms of (smallholder) innovation needs and draws from RTB FP1–FP4 products for testing in a whole system context (e.g., RTB crop waste such as cassava peels for livestock feed).

FP5 also provides opportunities for "docking" with other CRPs—for example, PB clusters will integrate work in Climate-Smart Villages of CCAFS in overlapping geographic areas. Other AFS-CRPs can also benefit from a systems perspective that not only takes into account interdependencies between different commodities and scales and trade-offs between different goals, but also includes the broader social and institutional context of livelihoods. Livestock and FTA CRPs provide key expertise on tree and livestock integration in farming systems. They bring expertise on systems research and participatory, demand-driven R4D (for cross-CRP collaboration see Annex 6). RTB and other AFS-CRPs have a predefined thematic focus: target commodities, technology innovations, and value chains define the boundaries of the innovation space. Little research support is given to enable decision-makers at the different (nested) scales to make an informed decision on the synergies and trade-offs of their investment choices, well beyond a single RTB enterprise. FP5 aims to provide support for socio-technical innovations and decision-making to users across nested scales and support investment decisions that will improve the livelihoods of smallholders—in particular, those of youth, women, and ethnic minority groups.

3. Enabling environment and Theory of Change

FP5 will explore synergies and trade-offs of RTB innovations with other on- and off-farm components e.g., (1) interactions between production methods and cultural landscapes, (2) between economic incentives and farm diversity, and (3) between farmers and other rural actors.

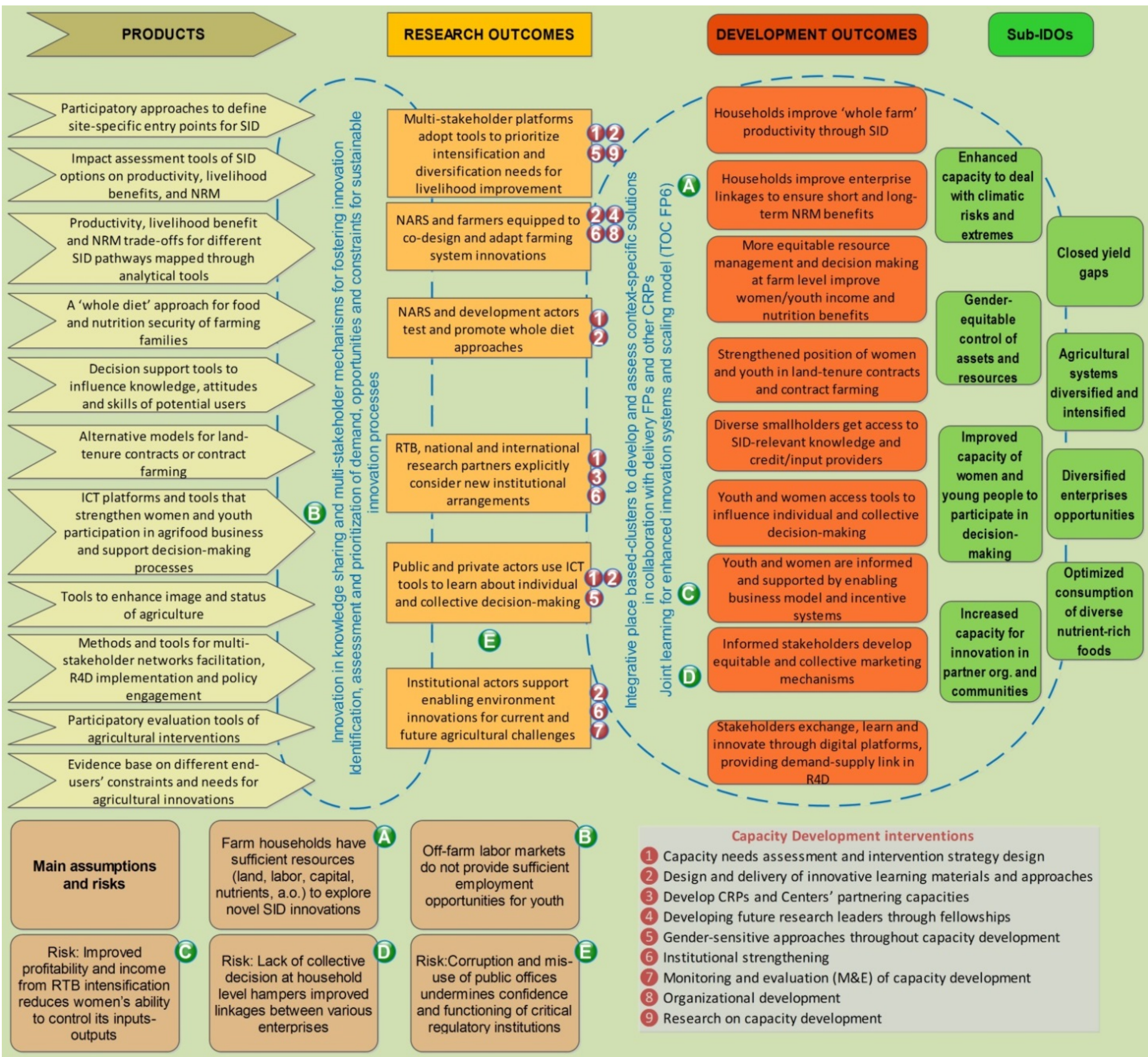


Figure FP5.1. Impact Pathway FP5—main risks/assumptions and capacity development interventions

The aim of FP5 is to improve synergies between RTB and non-RTB activities for more resilient whole farm productivity and household livelihoods. The impact pathway draws on and contributes to products from FP2–FP4. Whereas other FPs focus dominantly at plant, plot, and RTB value-chain levels, FP5 looks at the use of RTB innovations in a much broader systems context. R&D partners in other RTB flagships receive insights in end user demand and "supply" response from a diversity of actors in a diversity of sites. FP5 will draw on FP1–FP4 outputs to test these in a systems context, thereby including novel institutional innovations in PB clusters where international and local partners work together on common (Sub)-IDOs. At the local level, an enabling environment for innovation will be created through (1) multistakeholder identification and testing of SID options, building on Humidtropics innovation platforms; (2) participatory evaluation of SID results against SRF indicators (productivity, natural resource status, income, food and nutrition security, and gender and equity benefits); (3) quantification of SID synergies and trade-offs at farm and community levels; (4) proactive engagement with institutional partners, from the private and public sector to design impact pathways (FP6); and (5) improving partner's capacity to innovate to underpin all the above. Information exchange and learning will be strengthened through the use of digital technologies.

The PB approach will enable local decision-makers, ranging from men and women farmers to national policy actors, to formulate their needs/demands. This approach blends stakeholders' knowledge on productivity enhancement, to market drivers and natural resource management. As such, FP5 will build on national and regional policy and development priorities when developing the science agenda in the PB clusters, including gender and equity challenges.

Figure FP5.1 shows the key risks and assumptions for the logic of the ToC to play through, as well as capacity development interventions.

4. Geography and beneficiaries

PB clusters have been selected because of the current or potential contribution of RTB crops to livelihoods. A more detailed mapping and prioritization of research questions will take part during full proposal preparation. FP5 is currently focusing on four major geographies for the PB clusters (Table FP5.1).

Table FP5.1. (Sub)-IDOs, beneficiaries, and target countries for FP5

<table>
<tr><th>Target IDOs and
sub-IDOs</th><th>Total number of beneficiaries (2022)</th><th>Target countries</th></tr>
<tr><td>Increased incomes and employment

Diversified enterprise opportunities</td><td><u>Annual income increased at HH level</u>
PB5.3: 2,500,000 people; 40% income increase
PB5.4: 1,500,000 people; 40% income increase
PB5.5: 600,000 people; 40% income increase
PB5.6: 400,000 people; 40% income increase</td><td rowspan="3"><u>PB5.3:</u>
Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Uganda

<u>PB5.4:</u>
Cameroon, Ghana, Ivory Coast, Nigeria

<u>PB5.5:</u>
China, Vietnam

<u>PB5.6:</u>
Dominican</td></tr>
<tr><td>Increased productivity

Closed yield gaps through improved agronomic and animal husbandry practices</td><td><u>Annual farm-level productivity (food, feed, fiber, livestock products) increased (in value US$/ha)</u>
PB5.3: 300,000 HH; 60% productivity increase
PB5.4: 180,000 HH; 60% productivity increase
PB5.5: 70,000 HH; 60% productivity increase
PB5.6: 50,000 HH; 60% productivity increase</td></tr>
<tr><td>Improved diets for poor and vulnerable people

Optimized consumption of diverse nutrient-rich foods</td><td><u>Dietary diversity score improved for young children (6-23 months) and women of reproductive age</u>
PB5.3: 250,000 HH; at least 4 food groups
PB5.4: 150,000 HH; at least 4 food groups
PB5.5: 60,000 HH; at least 4 food groups</td></tr>
</table>

Target IDOs and *sub-IDOs*	Total number of beneficiaries (2022)	Target countries
	PB5.6: 40,000 HH; at least 4 food groups	Republic, Haiti, Peru
Enhanced benefits from ecosystem goods and services ***Agricultural systems diversified and intensified in ways that protect soils and water***	<u>Soil content of carbon and nutrient inputs restored (ha of farm land with positive nutrient and carbon balances)</u> **PB5.3:** 400,000 ha **PB5.4:** 240,000 ha **PB5.5:** 100,000 ha **PB5.6:** 60,000 ha	

5. Novelty of science

The SRF provides key targets for improved livelihoods and environmental functions, and RTB innovations will affect several targets simultaneously. FP5 will develop and apply integrated systems analysis tools to understand, communicate, and manage trade-offs and synergies between targets. Systems analysis helps to (1) identify efficiencies and constraints, (2) compare existing practices and strategies, and (3) explore possible futures (Giller 2013). Combined bio-economic modeling and participatory scenario analysis allow stakeholders to jointly describe the current system, explain how it functions, explore intervention trade-offs and synergies, and design alternative configurations in response to expected trajectories based on foresight analysis.

System-interventions are, by default, context- and site-specific; they need to go beyond single technologies, so as to deliver diversified options and allow mainstreaming of multiple solutions (Geels 2004). Innovation options depend on actor needs and perceived opportunities and constraints in their biophysical and socioeconomic setting. Understanding and using the diversity and interdependency of these actors and their underpinning drivers are key to developing innovations that fit within the "socio-ecological niche" (Ojiem et al. 2006). This requires novel transdisciplinary research and partnership approaches in the PB clusters.

CC5.1 Sustainable intensification/diversification. This cluster focuses on improving household benefits (income, food, nutrition, resilience) through better and more equitable resource management and decision-making at farm level. It embraces innovative approaches to improve whole-farm productivity and whole-diet diversity by considering system diversification and integration, including co-location of cash crop, minor crops, livestock, and tree product interventions. It will build on local and technical knowledge for sustainable intensification (Vanlauwe 2014) while minimizing trade-offs (e.g., risk of single commodity failure). It will exploit synergies (e.g., re-use of crop residues, improved labor efficiency) between farm activities, particularly tree-crop-livestock interactions. Equal importance is given to household decision-making, system productivity and diversity (income, food), and natural resource integrity. Policy, market, and institutional dimensions of farming systems are recognized and their dynamic interactions (CC5.2) with technology adoption needs to be understood when defining the "solution space" of SID. Farming systems at different levels of intensification require different best-fit technologies. The cluster is guided by the following research questions:

- What are the farm-level trade-offs and synergies that can allow for SID of RTB-based systems?
- How can SID options be adapted to different farms, based on resource limitations (e.g., land, labor, capital, nutrients) and on-/off-farm dependency?

Specific research outputs include (1) approaches to define site-specific entry points for SID of farming systems; (2) tools and methods to assess the impact of SID interventions on overall system productivity and natural resource integrity on the short and longer term; (3) a set of best-bet RTB SID options; (4) a whole-diet approach to integrate availability, accessibility, and composition dimensions of diverse diets for nutrition security; and (5) decision-support tools related to the above options for influencing the knowledge, attitudes, and skills of the next level of users in CC5.2.

CC5.2 Institutional innovations. Agricultural sciences, including RTB, have a strong reputation in developing technical solutions. In comparison, the capacity to analyze and test new institutional arrangements and options is notoriously weak (Leeuwis et al. 2014), while the need is high (Hounkonnou 2012). Here lies an enormous overarching scientific challenge that forms the inspiration for this cluster. Linking institutional innovation to digital opportunities to influence individual and collective decision-making is new and highly pertinent to the grand challenges. Therefore, this cluster sets out to design, develop, and test a range of institutional innovations. In doing so, it focuses on overcoming existing market, knowledge, and policy constraints that hamper (1) sustainable intensification and (2) youth engagement in agribusiness. The overall research questions guiding this crosscutting research cluster are:

- Which institutional options enable or hamper individual and collective decision-making for SID in RTB?
- What technical and institutional options support youth engagement (considering gender differences) in agri-business?
- How can digital technologies foster new exchange processes that enhance decision-making?

The cluster will study the processes that foster the design and testing of institutional innovations. Outputs may include new land tenure contracts, new models of contract farming, new price setting and certification systems, new digital platforms for the monitoring of natural resources, new digital tools that enhance the efficiency of the labor market, new agri-business and service delivery models for youth, and new images and incentive systems for enhancing the status and position of agriculture. The identification of repeating patterns across different regions and continents provides the basis for a comparative approach and identification of scaling lessons that feed into FP6.

PB5.3-PB5.6 Integrating science and partnerships in PB clusters. As reflected in Table FP5-1, innovation entry points in RTB-based farming systems differ strongly between regions. Through systems thinking (CC5.1-CC5.2) and participatory approaches, the PB clusters will help scientists and development actors to understand end users' needs and opportunities. In the PB clusters, the international, regional, and local partners will converge and co-develop solutions that are meaningful to the local conditions. The key hypothesis is that the PB approach is the most cost-effective way to develop “home-baked” solutions that can be taken to scale rapidly and sustainably without large and continued external support, providing lessons for FP6. The convergence of CC5.1 and CC5.2 in the PB clusters allows for transdisciplinary science that provides scientists within RTB (FP1–FP4; FP6) on agricultural innovation (Röling 2009). The PB clusters also allow for the docking with other CRPs, such as PB integration with Climate Smart Villages in CCAFS, creating further opportunities for joint research across environments and themes.

6. Previous projects/activities

FP5 will build upon projects and activities of Humidtropics and RTB. These include projects such as the Consortium for Improving Agriculture Based Livelihoods in Central Africa (CIALCA), the Policy Action for Sustainable Intensification of Ugandan Cropping systems project which develops Zonal Investment Plans for the potato-based farming systems in Uganda with Ministry of Agriculture, the FARA-led Sub-Saharan Africa Challenge Program, and FoodStart for Asia/Mekong. FP5 builds on the integrated systems research as pioneered under Humidtropics. This includes research on whole-farm productivity improvements (e.g., legume, livestock, and vegetable integration) into RTB crop-based systems and improvements of dietary diversity through diversification in RTB crop-based systems and analysis of nutrition-sensitive landscapes together with A4NH. RTB and Humidtropics collaborated on social science, such as a gender norms study that was conducted in East Africa. Tools to facilitate, track, and scale multistakeholder networks and policy engagement are available from Humidtropics and RTB.

Humidtropics research investments to adopt RBM helped to experiment with a new cluster of activities focused on the implementation of integrated systems research through innovation and R4D platforms. These platform research projects are small scale, with wider participation of stakeholders, based on RBM principles. They are building on systems approaches, including systems analysis, integrated systems improvement, and development of M&EL framework for improved monitoring of results, budgets, and enhanced decision-making by different levels of management. About 24 such livelihood systems research projects have been established by multistakeholder platforms under Humidtropics. Many address key challenges in RTB crop-based systems: (1) improving whole-farm productivity by optimal enterprise combinations in the mixed cocoa-RTB farming systems in West Africa; (2) improving agro-forestry and potato-based cropping system productivity as well as dietary diversity in tropical highlands of Northern Rwanda; (3) improvement of RTB crop-legume-livestock integration for improved income and human and animal nutrition in Mushinga DRC; (4) enhanced livelihoods and better natural resource management through appropriate integration and diversification on smallholder farms in the Central Highlands of Vietnam; and (5) improvement of RTB crop integration in coffee and cocoa agroforestry systems for improved income and nutrition in Northern Nicaragua and Haiti.

7. Partnership strategy

FP5 recognizes different types of partners: (1) science partners providing key science expertise on livelihood systems in the broadest sense; (2) national R4D actors co-leading multistakeholder network processes (e.g., platforms) where investment priorities, implementation, tracking, and learning will take place; (3) locally operating next users with interest in scaling up and out flagship innovations; and (4) advocacy, media, and ICT partners for knowledge-sharing (communication), awareness, and policy engagement approaches.

Table FP5.2. Key partnerships for FP5

Partner or player	Role in developing product or achieving outcome
International/(sub-)regional science partners	
ICRAF, ILRI	Expertise on crop-tree-livestock integration and platform expertise
WUR	Key expertise on social science, institutional innovation, and the potential of ICT as well as on farming systems analysis and trade-off modeling
AVRDC	Vegetable enterprise expertise for diversified RTB systems and diets
National/regional agricultural bodies	
NARS, local universities	Co-leading national-level research for development in PB target regions
Ministries of Agriculture and regional bodies (ASARECA, CORAF)	Provide insight in local policy, market and institutional barriers and incentives, and help design and test institutional innovations -> legitimacy and scaling
FARA	Africa Union Commission representative and platform/policy expertise policy
Private sector	
Multinational private sector actors such as Yara, Nestle, IDH, WCF, Rainforest Alliance	Involved when RTB-system technologies affect demand/supply of major trade commodities like fertilizer and cocoa, including product certification
Local private sector (e.g., producer and trade organizations)	Actively brought into the multistakeholder network approaches so as to ensure that innovations respond to their needs and opportunities

Partner or player	Role in developing product or achieving outcome
Development organizations/communication brokers	
Development organizations (e.g., CRS, Caritas, WorldVision, Diobass)	Provide insight in local policy, market and institutional barriers and incentives, and help design and test institutional innovations with end users
Advocacy, media, ICT experts	Brought in on a needs basis, both voluntary services or short term contracts
CGIAR CRPs (see also Annex 6)	
CCAFS	Testing role of RTB diversification in building resilience, e.g. in Climate-Smart Villages including maize systems (CCAFS F1)
WLE	FP5-AC1 on SID and trade-off analysis, FP6-AC4 on institutional innovation
PIM	Policy analysis and institutional innovation
A4NH	Human nutrition and whole-diet diversity versus biofortification
FTA	Mixed tree crop (coffee/cocoa) – RTB farming systems
LIVESTOCK	Crop-livestock interactions — RTB residue/waste re-use
RAFS	Mixed rice-RTB cropping systems in inland valleys
MAIZE	Exchange on sustainable intensification and systems analysis tools — MAIZE FP4

8. Capacity development

CapDev will be driven by clearly defined objectives along the impact pathway. Successful implementation of the strategy relies on the active and ongoing engagement of partners, especially with boundary partners and members of the multistakeholder networks/platforms. Implementing these capacities will take place at all levels through workshops and training-of-trainers approach, e-learning and blended learning, coaching, mentoring, formal training, and ICT tools to develop novel ways to support learning at scale.

CapDev takes a pro-active gender approach by (1) ensuring 50% or more female participation in implemented activities, (2) including ongoing gender evaluation at routine stages of the program to address any identified gender imbalances, and (3) adapting participatory approaches, including participants' preference on how to maximize benefits for women and youth.

CapDev involves many partners in multiple geographical and subject areas. Appropriate learning and communication approaches will ensure co-learning and information-sharing. CapDev focuses on:

- Trade-offs and synergy analysis within systems research
- Innovation systems and institutional innovation analysis
- Facilitation for multistakeholder engagement, including R4D and innovation platforms
- Action research and behavioral change methodologies focused on gender and youth
- Scaling approaches and processes, including key communication and engagement skills
- A postgraduate research fellowship scheme, aligned with the research within the flagship and preferably with local and international student "blends"
- M&EL for adaptive management and RBM.

FLAGSHIP PROJECT 6: IMPACT AT SCALE

FP6 aims to nurture a results-oriented culture among RTB centers and partners across the RTB program portfolio, based on a forward-looking analysis of trends, strong and equitable collaborative arrangements among partners and beneficiaries for scaling RTB solutions, and a critical assessment of outcomes and impact as part of institutional learning. Designed as a "learning and support" flagship, FP6 supports RTB's Discovery flagship (FP1) in outcome orientation and RTB's Delivery flagships (FP2–FP5) in achieving outcomes and impact at scale. FP6 consists of three cross-cutting clusters:

CC6.1 Knowledge, capacities, and partnerships for scaling enables R&D partners engaged in Discovery and Delivery flagships to benefit from methodological and institutional innovations for gender-responsive knowledge-sharing, CapDev, and impactful partnership and scaling models. CC6.1 helps to (1) customize market-ready RTB technologies based on the identification of end user needs and the use of ICT-smart communication strategies; (2) advance networks, portals, and other methods for knowledge translation and sharing; and (3) design and implement impactful partnership and scaling models for fostering and expanding innovation and for developing capacities for bringing RTB technologies to scale.

CC6.2 Strategic research and support for gender transformation responds to the need for a better appreciation of the diverse gender realities and needs within smallholder households and beyond. The cluster comprises (1) analysis of trade-offs in innovation processes linked to gender norms and agency; (2) gender-responsive learning and CapDev with partners; and (3) strategies for gender-equitable uptake of RTB innovations among low-income households, including their contributions to transformative outcomes for women.

CC6.3 Foresight and impact assessment improves the ability of RTB management/governance, researchers and practitioners, donors, and policymakers to assess current and anticipated impact of RTB research, guide research investments in RTB agri-food systems, ensure demand orientation and learning for RBM, and better address future opportunities and threats at local and global levels. Its overarching goal is to enhance RTB impact in a gender-equitable way. CC6.3 combines science-based horizon scanning and foresight modeling, with ex-post assessments to provide evidence of achieved impact.

1. Grand challenges

FP6 supports the other RTB flagships in their response to the grand challenges:

Growing importance of nutritious and diverse agri-food systems and diets. Agri-food systems and diets are shaped by diverse preferences and roles of food system actors. Societal and environmental change will reconfigure consumer preferences and production patterns. FP6 will support foresight studies to anticipate future changes and make sure that pipelines for improved varieties will deliver what is needed 20 years from now. FP6 will provide gender-differentiated insight on household decision-making over productive resources and consumer preferences for food and diet. It will promote effective scaling models involving public and private sector, civil society, and the media, based on knowledge-sharing, CapDev, and co-investments for improved seed systems, more resilient cropping and livelihood systems, and new processing and other value-adding options.

Climate change poses challenges on agriculture through increased weather extremes and shifts in pest and disease pressure. But it also opens new opportunities for RTB crops in replacement of other crops and through more efficient photosynthesis. FP6 will support ex-ante and ex-post assessments of adoption and performance of climate-smart varieties in diversified agri-food systems, and help customize knowledge-intensive technologies and practices for gender-differentiated responses to climate change.

Diminishing genetic resources of RTB crops will reduce options in the long run. FP6 will engage in foresight studies on drivers of declining RTB genetic diversity in light of land use change and livelihood dynamics, and in ex-post assessments of in-situ conservation models and their effects.

Postharvest losses and food safety are a major concern in perishable RTB crops. FP6 will analyze public-private and other institutional arrangements along RTB value chains for increased food safety, reduced postharvest losses, and gender-differentiated opportunities in relation to postharvest innovation.

2. Strategic relevance and comparative advantage

This flagship is critical for prioritization and targeting, sharpening of gender responsiveness, refinement of partnership strategies and scaling models, and enhancement of knowledge-sharing and CapDev across the RTB program portfolio. It draws on RTB's comparative advantage in relation to:

Bridging between biophysical and social sciences. Acknowledging the increased importance of interdisciplinary research and past successes (Thiele et al. 2001; Cernea & Kassam 2006; Prain et al. 2006), RTB has strengthened social sciences research during Phase I. This is particularly the case with respect to gender-responsive and value chain research and participatory approaches to the development of joint impact pathways and metrics systems with RTB stakeholders in the context of the RBM pilot (see Part 1, section 5).

Moving from research to large-scale development outcomes. RTB is developing innovative partnerships and scaling models for technology development and refinement. The RBM pilots have strengthened buy-in from public, private, and civil society stakeholders in RTB impact pathways, resulting in joint monitoring, evaluation and learning (M&EL) systems. These processes build on mechanisms and skills developed by RTB in areas such as networking (Bioversity International 2015), learning alliances (Lundy et al. 2012), and the theory and practice of partnerships (Horton et al. 2009; Wheatley et al. 2015).

Ensuring demand orientation and learning for impact through horizon scanning, global futures and strategic foresight, and ex-ante and ex-post impact assessments. Skills in foresight analysis acquired jointly through the PIM-led Global Futures and Strategic Foresight project are available through FP6.

Building on sound strategies for knowledge management, capacity development, gender integration, and gender transformation. RTB draws on valuable experiences in knowledge-sharing through social learning. Examples include and RTB research network analysis (ILAC), Bioversity's knowledge (ProMusa, MusaNet) and regional banana networks (BAPNET, BARNESA, Innovate Plantain, MUSALAC), CIAT's work on learning alliances, and CIP's participatory approaches (farmer field schools/business schools, Participatory Market Chain Approach). An emerging body of research findings on gender integration and transformation strengthens the gender responsiveness of RTB projects, as do the insights from the GENNOVATE study on the relationship between gender norms and agency and agricultural innovation.

3. Enabling environment and theory of change

The underlying assumption of this flagship is that significant contributions to the CGIAR (Sub)-IDOs and SLOs require RTB to develop approaches and tools for translating and brokering research outputs into client-specific products and practices, as well as to use appropriate partnership and scaling models that ensure large-scale impact. The impact pathway of FP6 (Fig. FP6.1) points at the integration with and the enhancement of the impact pathways of the other flagships in support of their outcomes. It shows how FP6 helps to achieve effective, equitable changes in end user behavior through client-specific packaging of products, the partnership and scaling models set in motion with different types of development actors, and associated capacity strengthening. It also indicates the important role of innovative M&EL systems that monitor progress towards impact and facilitate continuous improvement through learning and feedback.

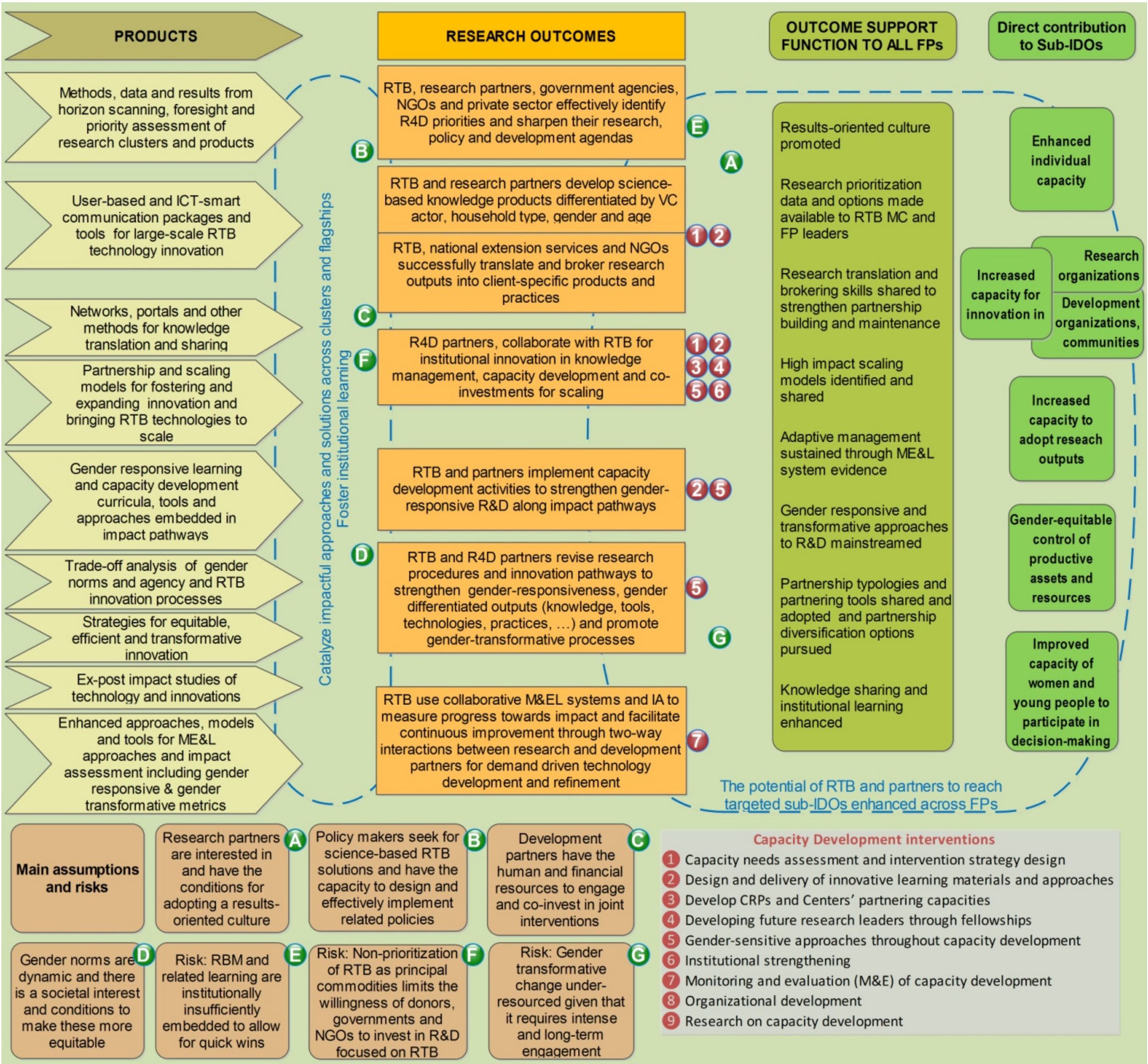


Figure FP6.1. Impact Pathway FP6—main risk/assumptions and capacity development interventions

Hence FP6's impact pathway flows through all the other FPs. CC6.1 will provide user-oriented mechanisms to enhance the targeting, development, evaluation, and two-way communication on technology innovations for a continuous cycle of experimental learning and technology refinement. CC6.2 will improve understanding of control over household assets that vary according to household type and gender. This will allow FP2–FP5 to customize technologies in line with (1) the different roles that crops play in diverse livelihood strategies; (2) the household assets available for cropping, processing, and marketing; and (3) gender-differentiated preferences for varietal traits, pest management, processing technologies, and value chain opportunities. CC6.2 will provide methodological guidance across all FPs for a common approach to gender-responsive and transformative research, and nurture learning through a community of practice around gender integration and transformation. CC6.3 provides outcome orientation leading to improved longer term targeting of RTB research across all flagships.

Figure FP6.1 shows key risks and assumptions for the logic of the ToC to play through, as well as CapDev interventions.

4. Geography and beneficiaries

In FP6, the quantified indicators (Table FP6.1) refer to the expected outcomes in support of the other FPs, with a broad range of beneficiaries across a variety of geographies (for details, see respective flagships).

Table FP6.1. Outcome indicators and outcome support delivered in FP6

Cluster	Outcome Indicators	Outcome support delivered
CC6.1 Knowledge, capacities, partnerships	• At least 1,500 users of RTB knowledge-sharing mechanisms with strengthened capacity for designing, implementing, and assessing RTB research • At least 264 stakeholder meetings for co-design of impact pathways and M&EL • 150 individuals (50% female) trained through long-term programs (e.g., MSc and PhD students) • At least 5 partnership and scaling models tested in a minimum of 5 target countries • At least 66 cases where RTB crops/technologies are newly included in policies or programs of government agencies, NGOs, and private sector	Enables RTB producers, processors, and users to articulate their needs for and improve their access to RTB technologies through innovative and inclusive institutional arrangements for sharing knowledge, developing capacities, and building partnerships to achieve impact at scale in terms of food and livelihood security.
CC6.2 Strategic gender research	• At least 1,440 research/development staff in RTB partner organizations with strengthened capacity in gender-responsive and transformative research • RTB delivery flagships and at least 55 R&D partners with more gender-responsive planning and implementation, reflected in 5+ collaborative arrangements with public sector and civil society organizations supporting gender transformation • 30% increase in partner organizations' communication and CapDev events with specific focus on gender transformation	Fosters gender-equitable access to livelihood and enterprise opportunities and risk mitigation mechanisms, with particular emphasis on genetic resources, food, markets, and productive assets.
CC6.3 Foresight, impact assessment	• At least 17 R&D partner organizations (5 regional and 12 national) in target regions and countries applying elements of foresight and priority assessment approaches in strategic planning • At least 15 ex-post impact assessments using low-cost methods based covering at least 45 crop-country combinations, for varietal adoption, changes in agronomic practices, and other key areas of agri-food systems • At least 5 large-scale and rigorous impact studies conducted	Improves the ability of donors, policymakers, and CGIAR researchers and practitioners to assess current and anticipated impact of RTB research, guides research investments in RTB crops, ensures demand orientation and learning as key elements of RBM, and better addresses future opportunities and threats at local and global levels

5. Novelty of science

FP6 addresses the following key research questions:

- How can novel approaches to knowledge brokering, translating and sharing, CapDev, and partnership arrangements help bring RTB innovations to scale?
- How do gender norms, practices, and men and women's capacity for action interact with RTB innovation processes? Which factors help narrow the gender gap, and which contribute most to more equitable and even transformative outcomes at scale?
- How can RTB research priorities be made responsive to socioeconomic, environmental, and institutional

trends in the near and long term? What evidence exists for impact of RTB research on smallholder livelihoods, their natural resource base, and RTB value chains? How can this impact be further scaled?

Each cluster includes specific elements of novel science and research innovation:

CC6.1 Knowledge, capacities, and partnerships will embark on systematic, comparative assessments of different models for taking technologies to scale, understanding context-specific elements, replicability, cost-efficiency, and ease or complexity of implementation. This research will draw on recent thinking in the literature on innovation systems (Hall 2012; Foran et al. 2014), organizational change (Sarapura et al. 2015), interface between technologies and policies (Crane 2014; Schut et al. 2014), and sustainability science (Kajikawa et al. 2014). Cases will cover enabling public policies (Qureshi et al. 2015), classic public sector extension systems (AfranaaKwapong and Nkonya 2015), public-sector/international donor co-financing schemes, communities of practice involving private sector actors, and different kinds of collaboration with civil society organizations—for example, in CIP's work on OFSP in Malawi (Abidin et al. 2015). Finally, novel research will be applied in relation to sharing knowledge on RTB innovations with specialist and non-specialist audiences to scale RTB's knowledge-sharing experiences (e.g., Bioversity's, CIAT's, and CIP's global and regional networks for banana, cassava, and potato/sweetpotato, respectively).

CC6.2 Strategic gender research will apply a mixed-methods approach for involving gender teams and biophysical researchers across RTB centers and partners in joint identification of effective interdisciplinary research tools to achieve two goals: (1) understand the gender dimension of specific research processes, such as collective action to control banana diseases; and (2) integrate gender analysis into research processes, so as to achieve gender-equitable outcomes. In addition, refined qualitative research approaches and tools derived from large-scale World Bank poverty studies will be used to analyze deep-seated gender dynamics that shape and are shaped by innovation processes (e.g., access to and use of land; gender norms for labor division, resource control, and decision-making). Further research innovations include (1) integration of the qualitative gender tools into large-scale, cross-CRP research efforts (GENNOVATE) to identify broad patterns where gender norms and men and women's agency interact positively or negatively with agricultural innovation processes; (2) inclusive approach to CapDev that strengthens gender integration R&D through exposure to gender concepts of thematic relevance and improving interdisciplinary skills and collaboration in mixed teams; (3) capitalizing on gender research capacity strengthened through the RTB-University Linkage Program involving mentoring by senior faculty of USA and European universities, placement of master students, and formation of a community of practice on gender in agricultural innovation that comprises RTB researchers and development practitioners; and (4) meta-analytical program evaluation approach to identify critical success factors for gender integration and transformation.

CC6.3 Foresight, impact assessment will develop a coherent framework to enhance RTB impact by using a harmonized set of approaches, state-of-the-art methods and tools to conduct priority-setting exercises, and impact studies in target countries and across RTB agri-food systems. These include (1) integrated use of biophysical and economic models for foresight analysis and ex-ante assessments, with improved data and parameterization of RTB crops and agri-food systems, and model comparison (e.g., economic surplus vs. computable general equilibrium; multi- vs. single-markets; static vs. dynamics; different output measures). The models will increase the robustness of the conclusions by looking at complementary results in a confidence interval. (2) Revealed and stated preference methods will be applied empirically in order to understand value chain actors' and end users' demand for priority traits in RTB crops, including consumer preference studies to identify demand for quality traits. (3) Different DNA fingerprinting techniques will be used to confirm genetic identity of RTB crop varieties in farmers' fields, complemented with the use of representative survey data to estimate adoption at national and regional levels. High-tech and low-cost methods will be combined to estimate adoption; complementary econometric techniques will be applied to analyze impact assessment data; new methods used to estimate direct and indirect beneficiaries of RTB interventions; and sex-disaggregated data collection protocols will be integrated into impact assessment data collection. (4) Novel data collection processes and storage protocols and templates will be developed in partnership with advanced research institutes, including tools to collect impact assessment data integrated with biological trials protocols. (5) Impact studies will be co-located in target countries of interest to several RTB agri-food systems, and a common database of varietal release and adoption estimates for RTB varieties and technologies will be developed. (6) A comparison will be made of baseline data from ex-ante analysis with information from ex-post impact assessments. This will include an impact assessment database of successful RTB technologies and adoption determinants to provide RTB with relevant feedback to refine directions of their research.

6. Previous projects/activities

FP6 will draw on a variety of experiences gained through RTB projects and initiatives, such as the following:

- FoodSTART, an RTB project in Asia led by CIP and CIAT, with alternative partnership models for taking innovations to scale. Working with large IFAD investment projects in different countries in Asia and using the farmer business school approach and enterprise development protocols, FoodSTART and the investment projects have elaborated different modes of collaboration in order to integrate these methodologies.
- GENNOVATE (Enabling gender equality in agricultural and environmental innovation) is a qualitative comparative field study reaching 125 villages across 26 countries. Research explores (bottom-up) differences in women and men's capacities to access, adopt, and benefit from innovations in agriculture and natural resource management. GENNOVATE represents a unique large-scale approach to fieldwork involving 11 CRPs. RTB co-leads the initiative through membership in a small Executive Committee. Upgraded qualitative methods are spreading beyond the GENNOVATE cases into other RTB work, and help reorient analysis leading to stronger publications (see, for example, Mudege et al. 2015).
- A pioneering RTB-wide priority assessment across five crops provided valuable insight and guidance on future investments in and returns on research (see Part 1, section 2 and https://goo.gl/qt7ZFy). It drew methodologically on earlier priority-setting work (Fuglie & Thiele 2009), creating a strong community of practice of impact specialists. Capacity in this area will guide RTB's pathway towards (Sub)-IDOs.
- With the better understanding of the role of research in innovation processes obtained in recent years, new research frameworks have been developed that emphasize interactions among researchers and a diverse set of collaborators. Developing methods and activities appropriate to the new framework has been difficult. RTB and ILAC have developed a methodology to monitor change in research portfolios and partnerships (actor networks). This information will be used by RTB and other CRPs to learn how they are moving along their impact pathways, to identify research areas of weakness and opportunity and to recognize gaps in the networks (Ekboir et al. 2013).
- The Diffusion and Impact of Improved Varieties in Africa (DIIVA) project updated productivity impacts of variety improvement research. The study collected data on varietal release, adoption, and impact for 20 food crops in 30 countries including cassava and yam (Alene et al. 2015), as well as potato and sweetpotato (Labarta 2015). DIIVA studies provide useful set of data for RTB planning in SSA. Another effort led by the Standing Panel on Impact Assessment, the Strengthening Impact Assessment in the CGIAR project, provides comparable information for Asia using low-cost methods of expert elicitation to record varietal release and estimate.

7. Partnership strategy

CC6.1 is particularly designed to support and strengthen partnerships that contribute to impact at scale. This will involve the identification and testing of different partnership models in operation or being planned within the discovery and delivery flagships.

Four broad types of development actors with whom partnership models for going to scale can be assessed. These are (1) selected large-scale development organizations able to fund scaling activities from their own resources; (2) large number of small-scale, low resourced public and civil society organization actors, often with good local knowledge and integration, but where scaling activities would need to be externally resourced; (3) (sub)-regional organizations and platforms as important agents for knowledge-sharing; and (4) private sector actors, sometimes with large networks (seed companies for example), who will be also part of the assessment. FP6 will establish the collaborative advantage of these partnerships through "Strengths, Weaknesses, Opportunities and Threats" analysis of organizational goals, characteristics, and culture in relation to end-user RTB technology needs (differentiated according to type, gender, and age) and to evaluate particular cases. In addition, two types of specialist partners are identified that will contribute to the development and refinement of approaches and tools: (1) other CRPs, especially the Global Integrating Programs but also some other AFS-CRPs (see Annex 6) and (2) advanced research institutes (e.g., in the framework of the RTB-University Linkage Program). Table FP6.2 presents key partnerships for FP6.

Table FP6.2. Key partnerships for FP6

Partner	Relationship and role in developing product or achieving outcome
Large-scale, well-resourced development actors	
BINGOs (CRS, Care, World Vision, Oxfam, Save the Children) public sector development projects (IFAD investment projects/ regional development bank projects; CRS, USAID, DFID, GIZ, SDC)	• Sharing and aligning of impact pathways with partners • Sequencing of types of collaboration (e.g., independent but complementary; joint activities with co-investments; commissioned research/training/ knowledge-sharing activities or outputs) • Contributing to large-scale uptake through awareness raising and CapDev • Responsibility for ME&L at scale • Providing customer feedback (gender and age-differentiated) and joint learning for technology refinement in given geographies (site integration)
Small-scale, low-resourced development actors	
Government agencies, local Civil society organisations, user groups/associations	• Provide ground-truth and link to local multistakeholder platforms • Help disseminate technologies and provide feedback for refinement • Users of M&EL tools from RTB/large-scale development partners
Regional/sub-regional organizations and platforms	
FARA and ASARECA in Africa, Learning Alliance for Sustainable, Inclusive Development, CATIE, IICA in LAC	• Facilitate dissemination of methods, tools, and practices • Facilitate knowledge-sharing of messages (nutrition, conservation, sustainable practices, etc.) • Focus of CapDev efforts
Private sector actors	
RTB input providers (seeds, fertilizers), small- and medium- food processors and other SMEs engaged in RTB value chains	• Knowledge of end user's preferences and markets • Effective and efficient distribution channels • Processing of RTB crops into nutritious and affordable foods • Co-investments in RTB value chain upgrading
Agricultural Research Institutions/Universities	
WUR, MSU, , Virginia Tech, Cornell, Guelph, N. American	• Innovative thinking in partnerships, innovation platforms, impact assessment • Innovative field collaboration and mentoring on gender research

Partner	Relationship and role in developing product or achieving outcome
universities with strong gender capacity, ALIGN, Partnering Initiative	• Insight into scaling models • Bridging social and biophysical sciences • State-of-the-art methods and tools for impact assessment
CGIAR CRPs (see also Annex 6)	
A4NH, CCAFS, PIM, WLE, RAFS, Maize	• Integration of impact pathways, sites, and M&EL systems • Co-location of scientists • Joint/complementary investments in tools development, partnering, and scaling • Horizon scanning and foresight analysis, policy analysis. • With CCAFS Learning Platform "Ex-ante evaluation and decision support for climate-smart options"

8. Capacity development

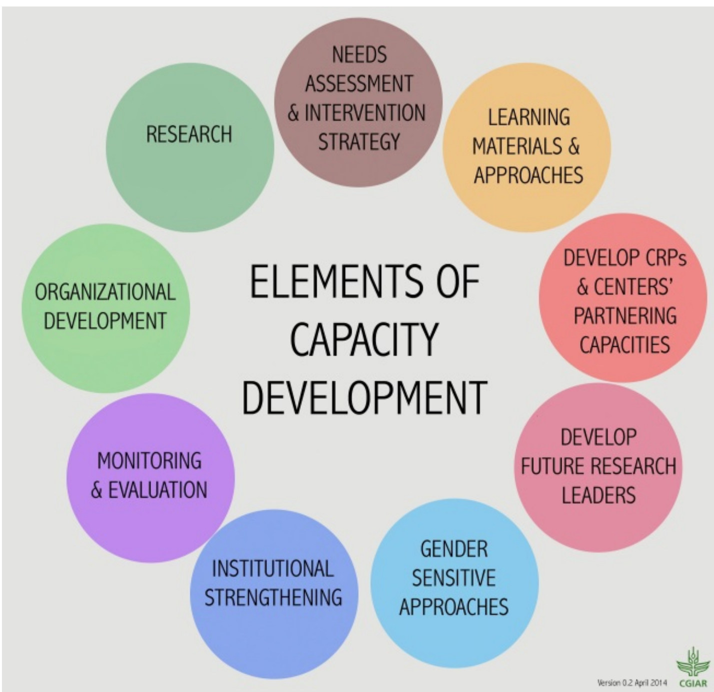


Figure FP6.2. Key types of CapDev supported

CapDev plays a critical role in achieving R&D outcomes and impact at scale.

CC6.1 and CC6.2 provide the foundation for the FP6 approach to CapDev as critical element of its outcome support. FP6 will articulate a strategy for RTB by drawing on the nine key elements of the CGIAR CapDev framework (CGIAR 2015) as identified in the impact pathway of each RTB-FP; diverse R&D partners will be supported.

FP6 will focus CapDev on researchers of RTB centers and international and national partner organizations to upgrade their skills for translating and customizing research outputs into products, and for brokering relations between diverse stakeholders. Expanded support for CapDev will be essential to achieve the targets laid out in this pre-proposal.

Refined approaches to CapDev will include case-based learning sessions around successful processes of knowledge translation and brokerage, and the identification of best practices and CapDev champions. Learning processes will be guided by the following questions:

- What CapDev models and mechanisms have the highest impact on customizing research outputs and bringing them to scale?
- Which opportunities exist for using ICTs for reaching development partners and farmers?
- Which other communication means and channels are needed for disseminating RTB outputs and receiving feedback for technology refinement as part of continuous improvement?

ANNEXES

ANNEX 1: CONSOLIDATED PERFORMANCE INDICTOR AND BUDGET MATRIX

Annex 1 presents the main outcomes and key targets by (Sub)-IDOs between 2017 and 2022.The budget is attributed by outcome, with management and gender contribution shown separately.

The Annex is available in an excel file attached to this main text (Annex 1 Performance Indictor Matrix_RTB_15_08_15).

RTB Pre-Proposal 2017 - 2022

Date prepared: 15-Aug-15

Annex 1: Consolidated Performance Indicator and Budget matrix

Name of CRP: *Roots, Tubers and Bananas Agri-food Systems*

Totals at CRP level: 791,111,522 | 24,583,142 | 85,857,074

Overall contribution to 2022 Targets in 2016 - 2030 SRF: See also Annex 3 "Table of target beneficiaries and target countries at CRP and Flagship level"for the high level contribution to specific targets set out in Table 1 of the 2016 - 20130 SRF.

			Expected Performance Outcomes (Quantified)							Budget Elements (US$)		
Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Flagship 1: *Discovery research for enhanced utilization of RTB genetic resources*										**157,558,305**	4,894,730	7,877,915
Increased productivity	Enhanced genetic gain	Outcome 1.1: Enhanced mapping of RTB diversity and selection of end-users preferred traits		5 new tools available for genomic mapping and editing	Markers for pest and disease traits developed and tested in 15 crop x pest/disease combinations	4 data management platforms linking genomic and breeding data under implementation		RTB high-yielding and resistant populations adapted to targeted environments available (For more details please refer to Table FP1.1)	Publication in open source data bases of data from extensive on-farm, farmer-managed multi-location trials throughout the target regions	31,511,661	978,946	-
Increased productivity	Increased conservation and use of genetic resources	Outcome 1.2: Accelerated discovery and incorporation of new traits into RTB breeding pipelines		Participatory methods for trait definition and selection (including at least 30% of female participants) used in 75% of RTB/partners joint activities		Platforms for high-throughput phenotyping under implementation for at least 4 RTB crops		100% of new populations integrating users-preferred traits, of which at least one third are women's preferred, included in national breeding programs	Annual reports of national breeding programs and other relevant partners	47,267,492	1,468,419	2,363,375
Enhanced benefits from ecosystem goods and services	Enrichment of plant and animal biodiversity for multiple goods and services.	Outcome 1.3: In-situ conservation of genetic resources enhanced through effective global networks		Baseline data for at least 2 target crops available in open access databases	Best practices and monitoring systems identified and characterized	Functional policies and incentive systems piloted in xx countries and recommendations formulated for dissemination of successful models		Conservation status of wild relatives and landraces of at least 3 RTB crops improved in 5 key hotspots	Publication in open source data bases of data and peer reviewed journals	23,633,746	734,209	-
Mitigation and adaptation achieved (CC)	Enhanced capacity to deal with climatic risks and extremes	Outcome 1.4: RTB breeding populations with enhanced resilience to climatic shocks introduced in delivery products pipelines			Platforms for high-throughput phenotyping for climate resilience under development for at least 4 RTB crops		Platforms for high-throughput phenotyping for climate resilience under implementation for at least 3 RTB crops	At least 25% of populations of banana, cassava, potato and sweet-potato with drought-tolerance considered for inclusion in breeding programs	Annual reports of national breeding programs and other relevant partners	23,633,746	734,209	-
National partners and beneficiaries enabled (CC)	Enhanced institutional capacity of partner research organizations	Outcome 1.5: Enhanced collaboration among partner institutions for more effective breeding	Breeding platform established in collaboration with at least 15 stakeholders in 6 countries		Breeding platform under implementation in collaboration with at least 20 stakeholders in 6 countries			Breeding platform under implementation in collaboration with at least 40 stakeholders in 10 countries	Annual reports of national breeding programs and other relevant partners	15,755,831	489,473	-
National partners and beneficiaries enabled (CC)	Enhanced individual capacity in partner research organizations through training and exchange	Outcome 1.6: Enhanced capacity of collaborator scientists through short and long term trainings		Partner institutions identify at least 20 candidates (at least 30% female) for advanced degree training		At least 15 candidates supported for advanced degree training, of which at least 30% are female		400 R&D partners, of which at least 30% are female, trained through short and long term programs	RTB annual report	15,755,831	489,473	5,514,541

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Flagship 2: ***Adapted productive varieties and quality seed of RTB crops***										**205,675,982**	6,391,712	14,397,319
Increased incomes and employment	Diversified enterprise opportunities	Outcome 2.1: Sources of income for RTB farmers and value chain actors diversified and increased		Rapid multiplication techniques for seed/planting material validated and framework to support best fitting options for different seed multipliers categories developed	Seed business models developed and under testing in at least 6 countries	New market-oriented approaches for diversified RTB products piloted in at least 5 countries	5,000 profitable decentralized seed business created, of which 30% are run by women and young people	20,000,000 people (4,000,000 HH), of which 50% are women, increased their annual income by increasing RTB sales and diversifying market strategies	Study reports (Household surveys, modelling)	30,851,397	958,757	1,439,732
Increased productivity	Closed yield gaps through improved agronomic and animal husbandry practices	Outcome 2.2: Increased adoption of production and post-harvest technologies		At least 6 crop and soil fertility management practices refined for new varieties	At least 1 Intergrated technology package (quality seed/improved varieties + ICM) per crop disseminated			Increased number of HH (at least 2,500,000) adopting improved agronomic practices for RTB ware and seed production	Adoption study reports	30,851,397	958,757	-
			Crop-specific evidences collected on the effect of genotype, management and environment on seed degeneration rate	Locally adapted and more effective storage structures developed	5 global and crop-specific decision support tools fine-tuned for an integrated management of seed degeneration		Increased number of farmer HH adopting improved post-harvest techniques, especially for on-farm seed management	Post-harvest losses reduced by 50% for 400,000 HH	Study reports (Household surveys)			
Increased productivity	Enhanced genetic gain	Outcome 2.3: On-farm yield of RTB sustainably increased		50% of candidate varieties (RTB-input) with full panel of user-preferred traits annually included in national trials for variety release		75% of varieties (RTB-input) with full panel of user-preferred traits annually released	Increased number of farmer HH adopting improved varieties	At least 5,000,000 HH increased their annual RTB yield by at least 10%	Adoption study reports, National statistics, National catalogues on variety released	47,305,476	1,470,094	-
Increased productivity	Increased conservation and use of genetic resources	Outcome 2.4: Enhanced use of RTB diversity	Gender-differentiated users-need and preferences for trait selection assessed in 15 countries and results communicated to orient breeding programs		Traditional knowledge of the landraces and wild relatives for banana in 5 countries documented for traits of importance, traditional uses, and other cultural and socio-economic aspects			Targeted breeding programs increased by 10% the diversity of the genetic base used (e.g. number of banana wild species used as parental lines)	Annual reports of national breeding programs and other relevant partners	10,283,799	319,586	1,439,732
Improved diets for poor and vulnerable people	Increased availability of diverse nutrient-rich foods	Outcome 2.5: Increased production of nutrient-rich RTB varieties		30% of candidate nutritious varieties (RTB-input) annually included in target country national trials for variety release		50% of nutritious varieties (RTB-input) annually released in target countries	3,500,000 households, of which at least 25% are female headed, adopting nutritious varieties	Annual production of RTB nutrient-rich varieties increased by 5-10% in target countries	National statistics, Study reports	32,908,157	1,022,674	1,439,732
Mitigation and adaptation achieved (CC)	Enhanced capacity to deal with climatic risks and extremes	Outcome 2.6: Improved availability of RTB varieties adapted to future climates	Climate responsive breeding targets developed for all crops in at least 5 target environments	40% of breeding populations showing improved resilience under fututre climates included in national breeding programs		20% of varieties released with drought tolerance and other traits of importance for resilience to future climates		Increased adoption of drought tolerant varieties in targeted countries	Study reports	10,283,799	319,586	-

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Equity and inclusion achieved (CC)	Gender-equitable control of productive assets and resources	Outcome 2.7: RTB women farmers improved their control over assets and resources	Baseline of gender roles in seed multiplication available in five countries/crops			Women's participation increased by 30% for the design of RTB supported capacity development and extension interventions in the field of seed multiplication / seed management / crop management designed	At least 25% of HH adopting improved varieties/seeds are female headed households	Increased % of female beneficiaries that perceive to have better control over assets and resources	Specific study reports and disaggregated data used in adoption studies and other documents.	8,227,039	255,668	7,198,659
Enabling environment improved (CC)	Conducive agricultural policy environment	Outcome 2.8: RTB seed and production systems supported through adapted national policies and regulations		Regulatory frameworks for seed production and seed quality control (including QDS) developed and under discussion in 10 countries	Benefit-sharing mechanisms protecting custodian farmers rights and facilitating the exchange of Musa genetic resources piloted in 3 countries and recommendations formulated	Regulatory frameworks for seed production and seed quality control (including QDS) approved in 10 countries	RTB included in national food security related policies and initiatives in at least 10 countries	Regulatory frameworks for seed production and seed quality control (including QDS) under implementation in10 countries	Analysis of national regulations of targeted countries	14,397,319	447,420	-
National partners and beneficiaries enabled (CC)	Enhanced individual capacity in partner research organizations through training and exchange	Outcome 2.9: Strengthened capacities for designing and implementing smallholder-oriented effective breeding programs and sustainable seed systems					150 individuals (50% female) trained through long term programs (e.g.MSc and PhD students)	8,000 R&D stakeholders annually trained (50% female) through short term programs	Consolidation of capacity development reports	20,567,598	639,171	2,879,464

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Flagship 3: *Resilient RTB crops*										**100,488,980**	3,122,295	7,034,229
Increased productivity	Reduced pre- and post-production losses, including those caused by climate change	Outcome 3.1: RTB yield restored in areas affected by key pests and diseases	Baseline of pest incidence and damage available for 10 countries	Best practices and novel approaches for quality seed systems and farmer/community action for IPM identified and tested in at least 10 countries	At least 5 user-specific and locally adapted IPM strategies refined	Locally adapted approaches for quality seed systems and farmer/community action for IPM disseminated in 20 countries	Individual and community strategies for IPM equally adopted by male and female farmers in 1,200,000 HH	In areas affected by pests and diseases, yield restored to previous infection conditions by 1,800,000 farmer HH, of which at least 25% are female headed households	Study reports (Household surveys, modelling)	18,088,016	562,013	-
Increased productivity	Closed yield gaps through improved agronomic and animal husbandry practices	Outcome 3.2: Household strategies for crop, soil fertility and water management improved		At least 5 gender-sensitive and site-specifc practices for crop, soil fertility and water management validated under diverse agro-ecologies	Development and testing of decision support systems for ICM in different agroecologies and for different crops	Multi-stakeholder initiatives for promoting refinement and scale of selected sustainable management practices under implementation in 10 countries	Gender-sensitive, context -specific agronomic practices adopted in 1,200,000 HH, of which at least 25% are female headed households	In areas affected by pests and diseases, yield restored to previous infection conditions by 1,800,000 farmer HH, of which at least 25% are female headed households	Study reports (Household surveys, modelling)	18,088,016	562,013	703,423
More sustainably managed agro-ecosystem	Increased resilience of agro-ecosystems and communities, especially those including smallholders	Outcome 3.3: RTB cropping systems resilience to pests and diseases threats and climate risks increased	Global Pest Risk Analysis (PRA) available for at least 3 target RTB pests and diseases	Epidemiological models for better understanding of host-virus-vector dynamics progressively adapted to diverse cropping systems and results documented		Results provided by prediction models used for the development of at least 50% of new sustainable management practices		1,700,000 ha under sustainable management practices	Study reports (Household surveys, modelling)	40,195,592	1,248,918	-
Mitigation and adaptation achieved (CC)	Enhanced capacity to deal with climatic risks and extremes	Outcome 3.4: RTB farmers strengthened their adaptation capacity to future climates	Downscaled climate change models linked to insect disease modelling for at least 5 major pest/regional combinations		90% of newly developed prediction models and PRA realized explicitly consider climate change effects		At least 60% of developed IPM/ICM management strategies assessed in terms of adaptation to future climates	At least 50% of developed IPM/ICM management strategies contribute in strengthening male and female farmers' adaptation capacity to climate change	Scientific publications and reports documenting on-farm trials	5,024,449	156,115	703,423
Equity and inclusion achieved (CC)	Gender-equitable control of productive assets and resources	Outcome 3.5: Equitable access to knowledge and innovations ensured	Gender differentiated needs assessment of capacity development available in at least 8 pest/country combinations		Women's participation increased by at least 30% for the design of RTB supported capacity development and extension interventions in the field of IPM and ICM	At least 33% of female participants ensured in all capacity development efforts (including extension services providing advice on ICM and IPM)		New technologies and practices have been adopted by equal percentages of female and male farmers	Adoption study reports	5,024,449	156,115	3,517,114

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Enabling environment improved (CC)	Conducive agricultural policy environment	Outcome 3.6: Integrated and multi-level strategies implemented by national and regional institutions for pests and diseases containment and eradication	Cost effective diagnostic tools and protocols developed for at least 3 key pests and diseases		25 National and 5 regional plant protection agencies with improved strategies for pests and diseases containment and management	Monitoring networks established in collaboration with NARS in 30 countries/regions to record the geographic distribution and incidence of chronic and emerging pests and diseases		25 National and 5 regional plant protection agencies with strategies for containment and management under implementation	Annual reports of relevant stakeholders, surveys	7,034,229	218,561	703,423
National partners and beneficiaries enabled (CC)	Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	Outcome 3.7: Increased capacity of partners and farmers for applying integrated approaches for crop and pests and diseases management	Engagement of stakeholders in impact pathway analysis for at least 3 cluster/country combination	R&D partners and farmers test in at least 3 initiatives user-specific and gender-sensitive models for technology refinement and scaling		R&D partners and farmers implement in at least 10 initiatives user-specific and gender-sensitive models for technology refinement and scaling		Number of extension services (govermental org., NGOs and private sector) providing advice on improved ICM and IPDM increased	Annual reports of relevant stakeholders, surveys	7,034,229	218,561	1,406,846

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Flagship 4: ***Nutritious RTB food and added value through post harvest intervention***										**73,358,623**	2,279,937	5,135,104
Increased incomes and employment	Diversified enterprise opportunities	Outcome 4.1: Increased income and employment opportunities in rural and urban areas through inclusive RTB value chains	RTB SME processing enterprises analysed in 5 countries, with a gender-sensitive approach, to identifiy opportunities for products improvement/ development	At least 6 processes and protocols for market demanded RTB products jointly defined with small and medium-scale processors and NARS	At least 4 processes and protocols for market demanded RTB products tested with small and medium-scale processors and NARS	At least 2 processes and protocols for market demanded RTB products under dissemination with small and medium-scale processors and NARS	Increased number of employments, of which 33% occupied by women and young people, created in RTB value chains (measured at intervention site level for selected countries)	700,000 households, 25% of which are female headed, have increased their income by 15-20% by increasing and diversifying RTB sales (food, feed, industrial raw material and seeds)	Study reports (household surveys)	14,671,725	455,987	513,510
Increased incomes and employment	More efficient use of inputs	Outcome 4.2: More efficient use of water and energy in RTB processing	Baseline of efficiencies and processing losses available for 5 local enterprise types in 3 countries	More efficient processing technologies and waste management options tested in at least 5 countries		More efficient processing technologies and waste management options disseminated in at least 5 countries		20,000 small scale cassava processors, 30 % of which are female, reduced water- and energy- related production costs by 15-20%	Published articles, study reports.	14,671,725	455,987	513,510
Increased productivity	Reduced pre- and post-production losses, including those caused by climate change	Outcome 4.3: RTB post-harvest losses reduced	Consumers and processors preferences assessed in 8 countries and results communicated to orient breeding programs and new RTB based food products	Locally-adapted and user-demanded storage technologies developed and tested in 8 countries	At least 70% of new processing technologies and protocols assessed to determine product losses	Locally-adapted and user-demanded storage technologies disseminated in 4 countries		Post-harvest losses of *xx HH reduced by 30%*	Study reports (household surveys, modelling)	11,003,793	341,991	-
Improved diets for poor and vulnerable people	Optimized consumption of diverse nutrient-rich foods	Outcome 4.4: Diet quality improved for RTB farmer households and urban/rual consumers	Assessment of nutritional impact of processing on x food/feed products documented	At least 6 locally adapted food preparation (fresh and processed) developed for OFSP and biofortified cassava		2,600,000 of consumers have access to affordable, safe and nutritious RTB-based fresh and processed food	Intake of vit-A rich food improved for 50% of women of reproductive age and children under 5 years of age in at least 2,000,000 HH	Diet diversity index increased by 20% for at least 2,000,000 HH	Study reports (household surveys)	18,339,656	569,984	1,540,531
Equity and inclusion achieved (CC)	Gender-equitable control of productive assets and resources	Outcome 4.5: Women increased their participation in and their benefit from RTB value chains	Gender analysis of RTB processing enterprises and linked input provision documented in 4 countries		Approaches for developing more inclusive RTB nutrition sensitive value chains refined and under implementation in 10 initiatives			Women engaged in selected RTB value chains perceive significant improvement interms of their control on productive assets and resources	Published articles, study reports.	5,868,690	182,395	2,567,552
Enabling environment improved (CC)	Conducive agricultural policy environment	Outcome 4.6: Multi-sectoral approach agriculture - nutrition - health promoted by national partners		Product quality and safety standards for RTB processed products and protocols developed or improved by national regulatory agencies in at least 3 countries	National food security and nutrition strategies in 8 countries emphasize the potential of RTB crops as energy and nutrient-rich foods		Increasing amount of RTB processed products complying with national quality and safety standards	Food-based nutrition programs/ initiatives promoting RTB crops under implementation in 10 countries	Annual reports of relevant stakeholders	4,401,517	136,796	-

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
National partners and beneficiaries enabled (CC)	Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	Outcome 4.7: National stakeholder with increased capacity for innovation in inclusive, integrated and market oriented approaches			Novel institutional arrangements (e.g. innovation platforms with NARS and equipment fabricators and small- and medium-scale processors) defined in 4 countries to foster innovation and scaling of technologies for RTB processing		10,000 individuals (e.g. bakers, processors, equipment fabricators, extension officers), of which at least 33% are female, trained in business and products development	60 partner development organizations, including women's netowrks and alliances, having increased their capacity for innovation (e.g. enhanced human capital and improved collaboration network in relevant domains)	Consolidation of capacity development reports	4,401,517	136,796	-

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Flagship 5: ***Integrated systems for improved livelihoods***										**165,309,213**	5,137,886	24,796,382
Increased incomes and employment	Diversified enterprise opportunities	Outcome 5.1: Income opportunities increased at household level	Income increased by 40% for at least 70,000 HH		Income increased by 40% for at least 200,000 HH		Income increased by 40% for at least 600,000 HH	Income increased by 40% for at least 1,000,000 HH	Study reports (household surveys)	24,796,382	770,683	-
Increased productivity	Closed yield gaps through improved agronomic and animal husbandry practices	Outcome 5.2: Whole-farm productivity increased	Whole-farm productivity increased by 60% for at least 30,000 HH		Whole-farm productivity increased by 60% for at least 108,000 HH		Whole-farm productivity increased by 60% for at least 330,000 HH	Whole-farm productivity increased by 60% for at least 600,000 HH	National Farm statistics and Household Survey Reports	36,368,027	1,130,335	2,479,638
Enhanced benefits from ecosystem goods and services	Agricultural systems diversified and intensified in ways that protect soils and water	Outcome 5.3: Restoration of degraded land enhanced through SID			100,000 ha of farm land with soil content of carbon and nutrient inputs restored		300,000 ha of farm land with soil content of carbon and nutrient inputs restored	525,000 ha of farm land with soil content of carbon and nutrient inputs restored		21,490,198	667,925	-
Improved diets for poor and vulnerable people	Optimized consumption of diverse nutrient-rich foods	Outcome 5.4: Diet quality improved especially for young children and women of reproductive age	Women of 15-49 years and children of 6-23 month in 20,000 HH consume at least 4 food groups (minimum dietary diversity score for adults under definition)		Women of 15-49 years and children of 6-23 month in 100,000 HH consume at least 4 food groups (minimum dietary diversity score for adults under definition)		Women of 15-49 years and children of 6-23 month in 350,000 HH consume at least 4 food groups (minimum dietary diversity score for adults under definition)	Women of 15-49 years and children of 6-23 month in 500,000 HH consume at least 4 food groups (minimum dietary diversity score for adults under definition)	National Health Statistics and Household Survey Reports	14,877,829	462,410	2,479,638
Mitigation and adaptation achieved (CC)	Enhanced capacity to deal with climatic risks and extremes	Outcome 5.5: Household capacity to deal with future climates improved	Capacity to deal with climate risks and extremes increased for at least 70,000 HH		Capacity to deal with climate risks and extremes increased for at least 200,000 HH		Capacity to deal with climate risks and extremes increased for at least 600,000 HH	Capacity to deal with climate risks and extremes increased for at least 1,000,000 HH	Study reports (household surveys)	4,959,276	154,137	2,479,638
Equity and inclusion achieved (CC)	Gender-equitable control of productive assets and resources	Outcome 5.6: Improved control of women and young beneficiaries over assets and resources	At least 35% increase in number of female and young beneficiaries of at least 10,000 HH perceive to have better control over assets and resources		At least 35% increase in number of female and young beneficiaries of at least 46,000 HH perceive to have better control over assets and resources			At least 35% increase in number of female and young beneficiaries of at least 200,000 HH perceive to have better control over assets and resources	Study reports (household surveys)	16,530,921	513,789	7,438,915
Equity and inclusion achieved (CC)	Improved capacity of women and young people to participate in decision-making	Outcome 5.7: Women and young beneficiaries increased their capacity to influence decision-makingat household and community level	At least 50% increase in number of female and young beneficiaries of at least 10,000 HH perceive to have increased decision-making capacity		At least 50% increase in number of female and young beneficiaries of at least 46,000 HH perceive to have increased decision-making capacity			At least 50% increase in number of female and young beneficiaries of at least 200,000 HH perceive to have increased decision-making capacity	Study reports (household surveys)	16,530,921	513,789	7,438,915

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
National partners and beneficiaries enabled (CC)	Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	Outcome 5.8: Stakeholders in action sites improved their learning and innovation capacity through multistakeholder mechanisms and more effective use of ICT	At least 1 systems innovation coalition established in each action site and problem identification and prioritization exercises conducted	a) At least 2 systems innovation coalitions established in each action site and problem identification and prioritization exercises conducted. b) At least 1 systems innovation coalition per action site experiment with prioritized alternative interventions options.		a) At least 3 systems innovation coalitions established in each action site and problem identification and prioritization exercises conducted. b) At least 2 systems innovation coalition per action site experiment with prioritized alternative interventions options. c) At least 1 systems innovation coalition per action site participates in trade-off analysis between selected alternative interventions options		a) At least 4 systems innovation coalitions established in each action site and problem identification and prioritization exercises conducted. b) At least 3 systems innovation coalition per action site experiment with prioritized alternative interventions options. c) At least 2 systems innovation coalition per action site participates in trade-off analysis between selected alternative interventions options	Annual reports of Innovation Coalitions and relevant stakeholders	29,755,658	924,820	2,479,638

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
Flagship 6: *Impact at scale*										**88,720,418**	2,756,582	26,616,125
Equity and inclusion achieved (CC)	Gender-equitable control of productive assets and resources	Outcome 6.1: Gender responsive and transformative approaches to R&D mainstreamed			RTB delivery flagships and at least 20 research and development partner organizations with more gender-responsive planning and implementation processes, reflected in at least 2 collaborative arrangements with public sector and civil society organizations supporting gender transformation			RTB delivery flagships and at least 55 research and development partner organizations with more gender-responsive planning and implementation processes, reflected in at least 5 additional collaborative arrangements with public sector and civil society organizations supporting gender transformation	Annual reports of relevant stakeholders	7,363,795	228,796	6,654,031
Equity and inclusion achieved (CC)	Improved capacity of women and young people to participate in decision-making	Outcome 6.2: Women's participation in RTB supported initiatives improved	10% increase in partner organizations' communication and capacity development events with specific focus on gender transformation	10% increase in women's (women farmers and scientist) participation in decision making as stakeholders in design of key RTB interventions	20% increase in partner organizations' communication and capacity development events with specific focus on gender transformation	20% increase in women's (women farmers and scientist) participation in decision making as stakeholders in design of key RTB interventions	30% increase in partner organizations' communication and capacity development events with specific focus on gender transformation	30% increase in women's (women farmers and scientist) participation in decision making as stakeholders in design of key RTB interventions	Annual reports of partner organizations, project proposals and stakeholder workshops reports	6,654,031	206,744	5,323,225
Enabling environment improved (CC)	Increased capacity of beneficiaries to adopt research outputs	Outcome 6.3: Research translation and brokering skills shared to strengthen partnership effectiveness	At least 44 bi-annual stakeholder meetings held across target countries for co-design of impact pathways and M&EL around implementation, including needs assessment and customized product development	At least 20 cases where RTB crops/technologies are newly included in policies or programs executed by government agencies, NGOs, and/or private sector	At least 44 bi-annual stakeholder meetings held across target countries for co-design of impact pathways and M&EL around implementation, including needs assessment and customized product development	At least 45 cases where RTB crops/technologies are newly included in policies or programs executed by government agencies, NGOs, and/or private sector	At least 44 bi-annual stakeholder meetings held across target countries for co-design of impact pathways and M&EL around implementation, including needs assessment and customized product development	At least 66 cases where RTB crops/technologies are newly included in policies or programs executed by government agencies, NGOs, and/or private sector	RBM reports, Annual reports of partner organizations and relevant stakeholders	14,816,310	460,349	2,661,613
National partners and beneficiaries enabled (CC)	Enhanced institutional capacity of partner research organizations	Outcome 6.4: Enhanced capacity of research partners for knowledge sharing and gender approaches to R&D		At least 300 research/development staff in RTB and in mixed-type partner organizations across prime target countries with strengthened capacity in gender-responsive and transformative research	At least 1,000 users of RTB knowledge sharing mechanisms with strengthened capacity for designing, implementing and assessing RTB research	At least 700 research/development staff in RTB and in mixed-type partner organizations across prime target countries with strengthened capacity in gender-responsive and transformative research	At least 1,500 users of RTB knowledge sharing mechanisms with strengthened capacity for designing, implementing and assessing RTB research	At least1440 research/development staff in RTB and in mixed-type partner organizations across prime target countries with strengthened capacity in gender-responsive and transformative research	Consolidation of capacity development reports	26,616,125	826,975	6,654,031
National partners and beneficiaries enabled (CC)	Enhanced individual capacity in partner research organizations through training and exchange	Outcome 6.5: Capacities of research staff in partner organizations strengthened		50 individuals (50% female) trained through long term programs (e.g.MSc and PhD students)		100 individuals (50% female) trained through long term programs (e.g.MSc and PhD students)		150 individuals (50% female) trained through long term programs (e.g.MSc and PhD students)	Consolidation of capacity development reports	3,726,258	115,776	2,661,613

Target IDOs	Target sub-IDOs	Flagship projects	2017	2018	2019	2020	2021	2022	Means of verifiying performance against outcomes (Note 3)	2017 - 2022 Total	Total dedicated to administration/ Management	Total dedicated to ensure gender-responsiveness
National partners and beneficiaries enabled (CC)	Increased capacity for innovation in partner development organizations and in poor and vulnerable communities	Outcome 6.6: Innovation process and mechanisms facilitated and high impact scaling models identified and shared	Comparative assessment of scaling models (desk study)	Design principles for at least 5 partnership and scaling models in a minimum of 5 target countries defined	First year performance of at least 5 partnership and scaling models in a minimum of 5 target countries assessed, and cross-country experiencves shared	Second year performance of at least 5 partnership and scaling models in a minimum of 5 target countries assessed, and cross-country experiencves shared	Third year performance of at least 5 partnership and scaling models in a minimum of 5 target countries assessed, and cross-country experiencves shared	At least 5 partnership and scaling models tested in a minimum of 5 target countriesand adjusted to be fit for purpose	Publications (e.g. policy briefs, working papers, impact studies)	29,543,899	917,942	2,661,613
			At least 2 ex-post impact assessments using low-cost methods based on expert workshops covering at least 6 crop-country combinations, to be undertaken in target countries with regard to varietal adoption, changes in agronomic practices, and other key areas of agrifood systems	At least 3 new ex-post impact assessments using low-cost methods based on expert workshops covering at least 9 crop-country combinations, to be undertaken in target countries with regard to varietal adoption, changes in agronomic practices, and other key areas of agrifood systems	At least 17 research and development partner organizations (5 regional and 12 national) in target regions and countries applying elements of foresight and priority assessment approaches in strategic planning	At least 5 new ex-post impact assessments using low-cost methods based on expert workshops covering at least 15 crop-country combinations, to be undertaken in target countries with regard to varietal adoption, changes in agronomic practices, and other key areas of agrifood systems	At least 5 new ex-post impact assessments using low-cost methods based on expert workshops covering at least 15 crop-country combinations, to be undertaken in target countries with regard to varietal adoption, changes in agronomic practices, and other key areas of agrifood systems	At least 5 large-scale and rigorous impact studies conducted				

ANNEX 2: GENDER SUMMARY

1. ***Gender analysis and priority assessment***

RTB management is committed to mainstreaming gender across research as essential to enhancing impact and gender equity. The RTB Gender Strategy (RTB 2013a) identified seven specific objectives where gender analysis could make the biggest difference to program outcomes.[3] RTB dedicated funding in Phase I to undertake gender analysis and gender integration research in these seven prioritized areas, and the findings have contributed to integrating gender into FPs proposed for Phase II.

Women are often the main producers, processors and beneficiaries of RTB crops. Despite that, often women's needs and concerns are not duly considered in agricultural research. For example, in Malawi women regard potato as a key cash and food crop but are rarely targeted with relevant agronomic advice to improve their potato yields, which are half of men's (Mudege et al., 2015). Women were also not targeted with marketing training which means that they cannot effectively participate and benefit from potato markets. A lack of attention to gender in innovation processes may even undermine women's livelihoods. In Kenya, the commercialization of banana value chains displaced women from producing and marketing the crop (Fischer and Qaim 2012). Exclusion has implications for efficiency and equity leading to agricultural underperformance in terms of yield (World Bank et al. 2009; FAO 2011).

Gender specialists took part in the cross-center team for the RTB priority assessment, (see Part 1, section 2), and various measures were taken to capture gender. Three gender questions were included among 90 research options in the expert survey to identify priority research areas. Expert respondents were asked to rank the importance of (1) R&D of gender-friendly labor-saving tools, (2) research on gender equitable value chains, and (3) study on gender inequality in crop production systems. The three gender research options were, however, ranked low compared with other research options. Probable reasons are:

- Lack of awareness of the importance of social aspects of technical research and focus on technical outputs rather than outcomes along the impact pathway.
- Lack of awareness of and inadequate capacity for integrating gender concerns, using available tools and undertaking gender analysis in agricultural R4D.

As a follow-up to the priority assessment, focus group discussions were initiated to identify the key gender implications of future RTB research in different locations. This fed into a separate, cross-CRP qualitative comparative field study, in which RTB is a leading proponent in design, training, and implementation: GENNOVATE (Enabling Gender Equality in Agricultural and Natural Resource Management). The three-year project started in 2013, involving 11 CRPs, and reaching 125 villages across 25 countries where CGIAR is active (RTB and Humidtropics have 20 cases in 7 countries). Research explores differences in women and men's capacities to access, adopt, and benefit from innovations in agriculture. Results will contribute to adjustments to the design of the RTB gender portfolio in Phase II.

In line with the scope of work outlined in the Gender Strategy and the findings of the priority assessment, RTB developed a gender capacity-strengthening plan (RTB 2013b) to raise awareness and build capacity among scientists and partners on the importance of gender mainstreaming and gender integration research. The team conducted an online (SurveyMonkey) Gender Training Needs Assessment, sent to 80

[3] (1) Develop a gendered understanding of indigenous knowledge and practice in the conservation and use of genetic resources. (2) Characterize gender-differentiated preferences for traits and their consequences, in order to help breeding strategies accelerate varietal development. (3) Develop information and communications strategies that inform both women and men of safe pest and disease control methods. (4) Improve access of men and women to quality planting material with gender-specific delivery systems where appropriate. (5) Ensure that crop management practices and other tools that are developed have the potential to be useful for both men and women. (6) Develop inclusive RTB market chains that improve gender equity in the distribution of benefits from increased commercialization. (7) Ensure that both men and women participate as RTB partners and that impact is measured from a gendered perspective.

staff and partners, 62 of whom responded. Lack of skills/trained staff, lack of financial resources for gender activities, and lack of input from gender scientists were frequently cited obstacles to gender integration. On the basis of this Training Needs Assessment, RTB developed a gender training curriculum with different flexible modules, and 80 scientists and partners were trained in Africa, Asia, and Latin America in 2013. Additional theme-specific capacity-strengthening efforts for partners were conducted on PVS (Ethiopia, Uganda) and nutrition (Ethiopia) in 2015. In addition, the team implemented an analysis of all gender research published by RTB centers between 2007 and 2012 (RTB 2013c). Three recommendations emerged from this analysis: (1) consider minimum gender standards in research, (2) strengthen gender content in the RTB portfolio, and (3) build stronger partnerships with key academic institutions to improve and increase the capacity to conduct gender research.

RTB has significantly increased financial and human resources for gender research. It has made dedicated funding available, hired a full-time gender research coordinator, and appointed gender focal points for each of the CGIAR centers. The gender team increased from two members in 2012 to nine in 2015. The team collaborates closely with the CGIAR Gender Network, providing inputs and developing indicators and metrics for the cross-cutting IDO on "Equity and inclusion achieved." Close collaboration with the Network has meant that RTB has influenced gender integration processes and aligned itself to gender work and targets at a wider CGIAR level (CGIAR 2013).

Against the backdrop of the scope of the different gender-related initiatives mentioned above, Table 1 gives a synopsis of gender analysis undertaken in Phase I, the FP it relates to, and the gender relevance of the FP, based on scoring its constituent clusters.

Table 1. Gender analysis undertaken in 2013–2015

<table>
<tr><th>Gender Analysis Done</th><th>Flagship</th><th>FP Gender Relevance</th></tr>
<tr><td rowspan="2">• Gender and trait preference for cassava, translation of local trait descriptions to standardized scientific terms (Nigeria, Cameroon)
• Sex-disaggregated analysis of PVS databases for potato; development of gender-responsive guidelines for "mother and baby" trials (Peru)</td><td>FP1: Enhanced genetic resources</td><td>0.7</td></tr>
<tr><td>FP2: Productive varieties & quality seed</td><td>1.8</td></tr>
<tr><td>• Gender analysis of potato seed systems (Malawi) and sweetpotato seed systems (Malawi, Bangladesh)
• Guidelines for gender mainstreaming in seed production and multiplication
• Development of a gender-mainstreamed RTB multistakeholder framework for intervening in seed systems</td><td>FP2: Productive varieties & quality seed</td><td>1.8</td></tr>
<tr><td>• Gender analysis of management of priority pests and diseases focusing on gender roles and gender knowledge in banana (Malawi, Burundi, DRC) and cassava (Thailand, Cameroon)</td><td>FP3: Resilient crops</td><td>1.7</td></tr>
<tr><td>• Gender analysis of value chains for cassava industrialization (Colombia); banana (Cameroon, Uganda, Rwanda, Burundi, Tanzania); sweetpotato (Kenya, Uganda, Tanzania); and potato (Peru; Sarapura-Escobar et al. 2015)
• Gender-responsive value chain tools and applications developed, implemented, and tested</td><td>FP4: Nutritious food & added value</td><td>1.8</td></tr>
<tr><td rowspan="2">• GENNOVATE: Project focusing on the role of gender norms in technological innovation.</td><td>FP5: Integrated livelihood systems</td><td>1.8</td></tr>
<tr><td>FP6: Impact at scale</td><td>2</td></tr>
</table>

*Legend: **0**=cluster that does not meet criteria of gender relevance or gender responsiveness; **1**= cluster satisfies one of the criteria; **2**=cluster includes both criteria. The final score is the average score across all clusters of that particular flagship.*

2. Operationalization of gender in the research agenda

2.1 Mainstreaming and integrating gender research

In Phase II RTB will ensure that gender is integrated across the portfolio, and that gender work is fully resourced. Gender work will adopt a two-pronged approach: (1) integrate gender within FPs and clusters, and (2) conduct strategic gender research across FPs, with a dedicated crosscutting gender learning and support cluster in FP6 (CC6.2 Strategic gender research). Strategic research will deepen the analysis of the relationship between gender and agri-food system innovation and thus help to streamline gender elements across the RTB research cycle. This, in turn, will contribute to gender-responsive and, in some cases, gender-transformative outcomes.

Integrating gender in R&D interventions. Gender integration research based on interdisciplinary collaboration will collect and analyze sex-disaggregated data on key areas in the different FPs and clusters. Key research areas will include the following: (1) gender-friendly labor-saving tools (trade-off analysis on technology/mechanization vs. women's workloads [FP5]); (2) research on gender-equitable value chains (FP2, FP4); (3) postharvest and nutrition (FP2, FP4, FP5); (4) gender inequality in crop production systems (FP3, FP5); (5) seed systems and varietal development (FP2); and (6) innovation processes for significant, equitable, and large-scale outcomes and impact (FP6).

Capacity development on gender integration and strategic research. RTB will revise and implement the CapDev plan that responds to the needs of researchers and experts, to achieve gender-responsive and -transformative outcomes. CapDev is expected to harmonize, strengthen, and improve the overall understanding of concepts and processes of gender analysis and integration of gender equity concerns in all flagships and clusters.

Synthesis of best practices, to facilitate and contribute to the development of a gender equity and inclusion toolbox. Although development of some tools has already started within RTB and the larger CGIAR gender network, other tools (e.g., those related to the measurement of intra-household distribution of income or gender and labor input) still need to be developed as a multi-CRP initiative. These tools will help gender work have greater impact through the use of "big data" and interoperable databases and the standardization of survey instruments to ensure collection of comparable data.

The synthesis will be based on a meta-analysis of experiences and results of gender integration research across the different FPs. Gender research will provide evidence-based lessons on the positive and negative interactions between gender norms and agricultural innovation; gender capacity development materials and strategies; and gender-responsive and -transformative metrics that will be fed into the RTB RBM system (via ToC and impact pathways).

Broad-based partnerships. The gender team will continue to build alliances through the RTB-University Gender Integration Partnership. This effort will increase capacity to integrate gender into RTB agricultural research projects, while providing professional development opportunities for a new generation of visiting scholars. RTB will also partner with NARES to mainstream gender, and will offer gender capacity development programs as well as mentoring by gender focal points in those institutions. Additionally, more emphasis will be given toward working with partners (such as FARA and ASARECA, women's network, self-help groups, gender alliances) who are oriented on gender equity and women's empowerment issues and who promote gender-equitable approaches.

2.2 *Tracking of progress and evaluation*

The following gender-responsive indicators will be tracked as part of the ME&L system in line with different (Sub)-IDOs and as outlined in the different flagships. Some of the gender indicators—especially those related to institutional change—are developed as a result of the various audits and needs assessment highlighted above, in collaboration with the CGIAR Gender Network:

- 25% of beneficiaries are female-headed farm households
- 70% of beneficiary female-headed households increase yield through adoption of improved varieties and sustainable management practices
- 50% of those with increased incomes are women
- At least 30% of 30,000 SMEs operating profitably in the RTB seed and processing sectors are headed by women

Additional indicators will be used to measure **gender-transformative** effects, such as women's empowerment, greater access to and control over resources, or decision-making capacity. These are in line with strategic gender research in FP6:

- At least 50% of the participants in capacity development training events are female
- At least 50% of R&D partner organizations in target countries are integrating gender into foresight and priority assessment approaches in strategic planning
- Percent increase in partner organizations' communication and capacity development events with regard to gender transformation
- 30% increase in women's (women farmers and scientists) participation in decision-making as stakeholders in design of key RTB interventions
- Increase in percentage of women who perceive that they are increasingly able to equally participate in and benefit from community farmer organizations at the same level as men.

Indicators will be logically tied to ToC and impact pathways across clusters and flagships. RTB's PMU and gender specialists will ensure that gender issues are addressed in the RTB portfolio through periodic workshops aimed at reviewing and reflecting on monitoring and knowledge-sharing. RTB will closely monitor changes for end users from pre-intervention situations; and will monitor, evaluate, and assess (ex-post) whether distribution of benefits is taking gender roles and relations into account.

In addition, RTB's PMU and gender specialists will develop templates to meet demand from scientists for guidelines to help them monitor whether or not the clusters are integrating gender aspects satisfactorily into their initiatives and are allocating sufficient resources for undertaking gender research. RTB will also conduct periodic assessment of gender knowledge among scientists to ensure that capacity development is adequately covered.

ANNEX 3: TABLE OF TARGET BENEFICIARIES AND TARGET COUNTRIES AT CRP AND FLAGSHIP LEVEL

Annex 3 is presented in an excel file, showing the RTB contribution to SRF targets, organized by SLOs, (Sub)-IDOs, RTB outcomes and respective beneficiaries and target countries. Tables are presented at CRP program level and Flagship Project level in two separate sheets inside the same file: (1) Annex 3-RTB CRP level, (2) Annex 3-RTB Flagship level.

The file name is: Annex 3 Table of beneficiaries_15_08_15

RTB Pre-Proposal 2017 - 2022

Annex 3: Table of target beneficiaries and target countries at CRP and Flagship level

Name of CRP **Roots, Tubers and Bananas Agri-food Systems**

RTB PROGRAM LEVEL

SRF target SLOs	Target IDOs	SRF targets 2022 to which RTB will contribute (Table 1 of the 2016 - 20130 SRF)	RTB total number of beneficiaries (Targets 2022)	RTB primary target countries
SLO 1 **Reduced Poverty**	**Increased incomes and employment**	SLO1- 2. 30 million people of which 50% are women, assisted to exit poverty	20,000,000 people (50% women) have increased their income 30,000 small and medium enterprises are operating more profitably in the RTB seed and processing sectors	**Africa:** Burundi Cameroon+ Congo DR Congo+ Ethiopia++ Ghana+ Ivory Coast Kenya+ Malawi+ Mozambique+ Nigeria++ Rwanda+ Tanzania++ Uganda+ Zambia+ **Americas:** Bolivia Colombia Ecuador Haiti Peru **Asia:** Bangladesh++ China India+ Indonesia Nepal+ Philippines Thailand Vietnam++
	Increased productivity	SLO1-1. 100 million more farm household have adopted improved varieties, breeds or trees, and/or improved management practices SLO2-1. Improve the rate of yield increase for major food staples from current <1% to 1.2-1.5%/year	8,000,000 farm households have increased RTB yield through adoption of improved varieties and sustainable management practices	
SLO 2 **Improved food and nutrition security for health**	**Improved diets for poor and vulnerable people**	SLO2-2. 30 million more people, of which 50% are women, meeting minimum dietary energy requirements SLO2-3. 150 million more people, of which 50% are women, without deficiencies of one or more of the following essential micronutrients: iron, zinc, iodine, vitamin A, folate, and vitamin B12 SLO2-4. 10% reduction in women of reproductive age who are consuming less than adequate number of food groups	10,000,000 people (50% women) have improved their diet quality (measured by diet diversity indices)	
SLO3 **Improved natural resources systems and ecosystems services**	**Enhanced benefits from ecosystem goods and services**	SLO3-1. 5% increase in water and nutrient (inorganic, biological) use efficiency in agro-ecosystems, including through recycling and reuse SLO3-3. 55 million hectares (ha) degraded land area restored	800,000 ha of farm land with soil carbon and nutrients content improved	
	More sustainably managed agro-ecosystem		1,700,000 ha of current RTB production area converted to sustainable cropping systems	

Note: The 26 primary target countries where RTB crops are of greatest importance include 17 of the 20 prioritized for CGIAR (2015) site integration (+) and all 6 of those fast-tracked for more intensive integration (CGIAR 2015).

Date prepared: 8/15/2015

RTB Pre-Proposal 2017 - 2022

Annex 3: Table of target beneficiaries and target countries at CRP and Flagship level

Name of CRP **Roots, Tubers and Bananas Agri-food Systems**

RTB FLAGSHIP PROJECT LEVEL

RTB Flagship main outcomes	Target IDOs and Sub-IDOs	Total number of beneficiaries (Targets 2022)	Target countries	Key assumptions
Flaship 1: Discovery research for enhanced utilization of RTB genetic resources				
Enhanced rates of genetic gain for end user-demanded traits	**Increased productivity** *Enhanced genetic gain* *Increased conservation and use of genetic resources*	**Breeding populations with target levels of genetic gain for key traits achieved** For details please refer to Table FP1.1.	Global	Increasing number of national governments enforce international treaties on genetic resources conservation and germplasm transfer Clear and harmonized frameworks approved at national and international level for authorization of genetically modified organisms National and international investments mobilized for strengthening NARS capacities (equipments and skilled personnel) Risk: Discovery research will inherently have a low success rate for individual tools and technologies (counter-balanced by high payoff for successful ones)
	Enhanced benefits from ecosystem goods and services *Enrichment of plant and animal biodiversity for multiple goods and services*	**Conservation status of wild relatives and landraces improved** At least 3 RTB crops in 5 key hotspots		
Flaship 2: Adapted productive varieties and quality seed of RTB crops				
Yield gaps arising from poor planting material closed Income generated in more equitable and inclusive RTB value chains diversified and increased	**Increased productivity** *Increased conservation and use of genetic resources* *Enhanced genetic gain* *Closed yield gaps through improved agronomic and animal husbandry practices*	**Yield increased at farm household level** BA2.2: 3,000,000 HH: 10–15% yield increase CA2.3: 2,800,000 HH: 20–50% yield increase PO2.4: 660,000 HH: 20–40% yield increase PO2.5: 1,280,000 HH: 7–40% yield increase SW2.6: 2,000,000 HH: 50% yield increase YA2.7: 1,200,000 HH: 40% yield increase **Postharvest losses reduced at farm household level** YA2.7: 400,000 HH: 50% reduced postharvest losses	**BA2.2** **Africa:** Burundi, Cameroon, Ivory Coast, DRC, Gabon, Ghana, Guinea, Kenya, Nigeria, Rwanda, Tanzania, Uganda **Americas:** Brazil, Colombia, Costa Rica Ecuador, Cuba, Dominican Republic, Haiti, Honduras, Mexico, Nicaragua, Panama, Peru, Venezuela **Asia**: India, Indonesia, Philippines **CA2.3** **Africa:** Cameroon, DRC, Ghana, Kenya, Malawi, Mozambique, Nigeria, Sierra Leone, Tanzania, Uganda, Zambia **Americas:** Brazil, Colombia, Cuba, Ecuador, Haiti, Paraguay, Peru, Venezuela **Asia:** Cambodia, China, India, Indonesia, Laos, Philippines, Thailand, Vietnam **PO2.4** **Africa:** Burundi, Cameroon, DRC, Ethiopia, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda **PO2.5** **Asia:** Bangladesh, China, India, Indonesia, Kazakhstan, Nepal, Uzbekistan, Vietnam **SW2.6** **Africa:** Angola, Benin, Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda, Zambia **Asia:** Bangladesh, India, Indonesia, Papua New Guinea Caribbean: Haiti **YA2.7** **Africa**: Benin, Ghana, Ivory Coast, Nigeria and Togo	Long-term, stable funding is available for active and efficient RTB conventional breeding programs Farmer are willing and able to pay for qulity planting material and/or improved varieties Regulatory agencies with adequate human and financial resources ensure effective control of seed quality Extension servicies, with adequate resources, effectively support innovation processes and technology adaptation and dissemination Poor development of smallholder-oriented and gender-sensitive credit and insurance products will negatively affect their innovation capacity
	Increased incomes and employment *Diversified enterprise opportunities*	**Annual income/ha increased** CA2.3: 14,000,000 people – $116 (average) PO2.5: 6,4000,000 people – $171 (average) YA2.7 1,200,000 people – $700 (average) **Diversified opportunities for income generation in RTB value chains enhanced, especially for women and youth** BA2.2: 50,000 women entrepreneurs PO2.4: 1,000 seed multipliers YA2.7: 4,000 seed multipliers		
	Improved diets for poor and vulnerable people *Increased availability of diverse nutrient-rich foods*	**Annual production increased** PO2.4: 3–5% in target countries PO2.5: 12% in cereal-based systems **Availability of nutrient-rich foods** BA2.2: Vitamin A-rich banana cultivars available for 500,000 people PO2.4: Micronutrient-dense (Fe & Zn) potatoes available to 20,000 people		

RTB Flagship main outcomes	Target IDOs and Sub-IDOs	Total number of beneficiaries (Targets 2022)	Target countries	Key assumptions
Flagship 3: Resilient RTB crops				
Yield gaps arising from biotic and abiotic threats closed Enahnced resilience and ecological sustainability of production systems	**More sustainably managed agro-ecosystem** *Increased resilience of agro-ecosystems and communities, especially those including smallholders*	**RTB production area converted to sustainable cropping systems** BA3.5: 515,000 ha CA3.6: 500,000 ha CA3.7: 1,000,000 ha **New areas infected reduced** BA3.3: Losses of cultivated area (ha) reduced by 20%	**BA3.3** **Africa:** Mozambique, Tanzania, Malawi, Kenya, South Africa **Asia:** Philippines, Indonesia, Papua New Guinea, Malaysia, China, Vietnam, Laos, Thailand South America and Caribbean: Brazil, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, Nicaragua, Peru **BA3.4** **Africa:** Angola, Benin, Burundi, Cameroon, DRC, Central African Republic, Equatorial Guinea, Gabon, Republic of Congo, Malawi, Nigeria, Rwanda, Zambia, Uganda, Tanzania, Ghana, Togo, Zimbabwe **Asia:** Philippines, Indonesia, Sri Lanka, Vietnam, Myanmar, Thailand, Papua New Guinea **BA3.5** **Africa:** Angola, Burundi, Kenya, Rwanda, Tanzania, Uganda **CA3.6** **Asia:** Cambodia, China, Indonesia, Laos, Philippines, Thailand, Vietnam Central and South America: Brazil, Colombia, Costa Rica, Nicaragua, Panama, Paraguay, Venezuela **CA3.7** **Africa:** Angola, Benin, Burundi, Cameroon, Congo, DRC, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Tanzania, Togo, Uganda, Zambia	Extension servicies, with adequate resources, effectively support innovation processes and technology adaptation and dissemination Increasing demand of RTB as food and feed contribute to farm-gate price stability/increase Sustainabily managed agro-ecosystems result in equal or higher profitability fro RTB stakeholders Risk: increasing demand and prices stimulate indiscriminate use of fertilizer and chemicals to increase productivity with negative environmental effects
	Increased productivity *Reduced pre- and post- production losses, including those caused by climate change* *Closed yield gaps through improved agronomic and animal husbandry practices*	**Yield losses reduced at farm household level** CA3.6: 340,000 HH; 20% reduction in yield losses **Yield restored at farm household level** BA3.3: 520,000 HH; yield = 80–100% of pre-FOC infection BA3.4: 380,000 HH; yield = 100% of pre-BBTD infection BA3.5: 1,000,000 HH; yield = 85% of pre-BXW infection **Yield increased at farm household level** CA3.7: 1,300,000 HH; 25–30% yield increase NB. For all clusters, innovative practices are expected to be equally adopted by female and male farmers and at least 25% of the beneficiary households would be female headed (see PIM for more details)		
Flagship Project 4: Nutritious food and value added through post-harvest innovation				
Diet diversity and micronutrient intake improved for poor and vulnerable people Income generated in more equitable and inclusive RTB value chains diversified and increased	**Improved diets for poor and vulnerable people** *Optimized consumption of diverse nutrient-rich foods*	**Dietary diversity score (DDS) increased** CA4.3: 20% increase in DDS; 1,400,000 HH SW4.4: 20% increase in DDS; 2,000,000 HH NB: All households members and particularly children under 5 years, women of reproductive age, and the vulnerable **Consumption of vitamin A-rich foods increased** CA4.3: 50% of children under 5 years of age consume vitamin A-rich foods at least twice in a week; 1,200,000 HH SW4.4: 50% of children under 5 years of age consume vitamin A-rich foods at least twice in a week; 2,000,000 HH CA4.3: 50% of women of reproductive age; 30% increase in intake of vitamin A-rich foods; 1,000,000 HH SW4.4: 50% of women of reproductive age; 40% increase in intake of vitamin A-rich foods; 2,000,000 HH **Risks associated with unsanitary and poorly processed cassava reduced** CA4.2: 2,600,000 consumers	**CA4.2** **Africa:** Benin, Cameroon, Ghana, Nigeria, Tanzania, Uganda **Americas:** Brazil, Colombia **Asia and Pacific:** India, Indonesia, Malaysia, Philippines **CA4.3** **Africa:** Angola, Benin, Cameroon, Congo, Côte d'Ivoire, DCR, Gabon, Ghana, Kenya, Liberia, Malawi, Mozambique, Nigeria, Rwanda, Sierra Leone, Tanzania, Uganda, Zambia **Americas:** Brazil, Colombia, Haiti, Guatemala **Asia:** Indonesia, Philippines SW4.4 Africa: Angola, Benin, Burkina Faso, Burundi, Ethiopia, Ghana, Kenya, Madagascar, Malawi, Mozambique, Nigeria, Rwanda, Tanzania, Uganda, Zambia **Asia:** Bangladesh, India, Indonesia, Papua New Guinea **Caribbean:** Haiti	Low price and interesting nutritional quality of RTB by-products stimulate their integration in animal feed production. Risk: regulatory agencies not adequately funding to ensure effective control on RTB food safety and quality standards. Risk: Competition between food and feed/energy/industrial uses reduce access to RTB crops for poor people. Risk: establishment of large scale processing unit exclude small and medium processors from the market with negative effects on equity and inclusion
	Increased incomes and employment *Diversified enterprise opportunities* *More efficient use of inputs*	**Annual household revenue improved through increased and diversified sales (food, feed, industrial raw material and seeds)** CA4.3: 2,000,000 people; 20% revenue increase SW4.4: 1,500,000 people; 15% revenue increase **Production cost reduced** CA4.2: 20,000 small- and medium-scale processors; 15–20% energy and water savings		

RTB Flagship main outcomes	Target IDOs and Sub-IDOs	Total number of beneficiaries (Targets 2022)	Target countries	Key assumptions
Flagship 5: Integrated systems for improved livelihoods				
Livelihood opportunities increased in RTB-based agri-food-systems	**Increased incomes and employment** *Diversified enterprise opportunities*	**Annual income increased at household level** PB5.3: 2,500,000 people; 40% income increase PB5.4: 1,500,000 people; 40% income increase PB5.5: 600,000 people; 40% income increase PB5.6: 400,000 people; 40% income increase	**PB5.3:** Burundi, Democratic Republic of Congo, Ethiopia, Kenya, Rwanda, Uganda **PB5.4:** Cameroon, Ghana, Ivory Coast, Nigeria **PB5.5:** China, Vietnam **PB5.6:** Dominican Republic, Haiti, Peru	Farm households have sufficient resources (land, labor, capital, nutrients, a.o.) to explore novel SID innovations Off-farm labor markets do not provide sufficient employment opportunities for youth Risk: Improved profitability and income from RTB intensification reduces women's ability to control its inputs-outputs Risk: Lack of collective decision at household level hampers improved linkages between various enterprises Risk:Corruption and mis-use of public offices undermines confidence and functioning of critical regulatory institutions
	Increased productivity *Closed yield gaps through improved agronomic and animal husbandry practices*	**Annual farm-level productivity (food, feed, fiber, livestock products) increased (in value USD/ha)** PB5.3: 300,000 HH; 60% productivity increase PB5.4: 180,000 HH; 60% productivity increase PB5.5: 70,000 HH; 60% productivity increase PB5.6: 50,000 HH; 60% productivity increase		
	Improved diets for poor and vulnerable people *Optimized consumption of diverse nutrient-rich foods*	**Dietary diversity score improved for young children (6-23 months) and women of reproductive age** PB5.3: 250,000 HH; at least 4 food groups PB5.4: 150,000 HH; at least 4 food groups PB5.5: 60,000 HH; at least 4 food groups PB5.6: 40,000 HH; at least 4 food groups		
	Enhanced benefits from ecosystem goods and services *Agricultural systems diversified and intensified in ways that protect soils and water*	**Soil content of carbon and nutrient inputs restored (ha of farm land with positive nutrient and carbon balances)** PB5.3: 400,000 ha PB5.4: 240,000 ha PB5.5: 100,000 ha PB5.6: 60,000 ha		
Flagship 6: Impact at scale				
Enabling factors for sustainable development enhanced	**Equity and inclusion achieved (CC)** *Gender-equitable control of productive assets and resources* *Improved capacity of women and young people to participate in decision-making*	RTB delivery flagships and at least 55 research and development partner organizations with more gender-responsive planning and implementation processes, reflected in at least 5 additional collaborative arrangements with public sector and civil society organizations supporting gender transformation 30% increase in women's (women farmers and scientist) participation in decision making as stakeholders in design of key RTB interventions	Global	Research partners are interested in and have the conditions for adopting a results-oriented culture Policy makers seek for science-based RTB solutions and have the capacity to design and effectively implement related policies Development partners have the human and financial resources to engage and co-invest in joint interventions Gender norms are dynamic and there is a societal interest and conditions to make these more equitable Risk: RBM and related learning are institutionally insufficiently embedded to allow for quick wins Risk: Non-prioritization of RTB as principal commodities limits the willingness of donors, governments and NGOs to invest in R&D focused on RTB Risk: Gender transformative change under-resourced given that it requires intense and long-term engagement
	Enabling environment improved (CC) *Increased capacity of beneficiaries to adopt research outputs*	At least 66 cases where RTB crops/technologies are newly included in policies or programs executed by government agencies, NGOs, and/or private sector		
	National partners and beneficiaries enabled (CC) *Enhanced institutional capacity of partner research organizations* *Enhanced individual capacity in partner research organizations through training and exchange* *Increased capacity for innovation in partner development organizations and in poor and vulnerable communities*	At least 1440 research/development staff in RTB and in mixed-type partner organizations across prime target countries with strengthened capacity in gender-responsive and transformative research 150 individuals (50% female) trained through long term programs (e.g.MSc and PhD students) At least 5 partnership and scaling models tested in a minimum of 5 target countries and adjusted to be fit for purpose At least 5 large-scale and rigorous impact studies conducted		

ANNEX 4: TECHNICAL COMPETENCY

In the case of FP4 the selection process is on-going and the CVs of all three candidates are provided.

4.1 PROGRAM DIRECTOR

Graham THIELE

Expertise

- Building a shared vision and mobilizing people and resources
- Strategic leadership and facilitation of multi-country research teams involving diverse partners
- Understanding and promoting innovation processes in varietal adoption, value chains and seed systems
- Priority setting, adoption studies, impact assessment and evaluation approaches
- Participatory research and extension methods
- Project proposal development and project management
- Commitment to improving the well-being of the poor and gender equity through agricultural research

Education:

Ph.D., Social Anthropology, 1983, Cambridge University, Cambridge, United Kingdom

M.Sc., Agricultural Economics, 1983, Wye College, University of London, London, United Kingdom,

Employment:

- 2012-2015. Director RTB. International Potato Center (CIP), Peru
- 2006-2011. Leader of Impact Enhancement Division. International Potato Center, Peru
- 2002-2006. Head of Mission. CIP, Ecuador
- 1998-2006. Coordinator Papa Andina Initiative. CIP, Bolivia and Ecuador
- 1994-1998. Technology transfer specialist. CIP, Bolivia
- 1990-1994. Technical Cooperation Officer. Overseas Development Administration (ODA – now DFID) Bolivia
- 1985-1989. Technical Cooperation Officer. Regional Development Corporation, ODA, Santa Cruz, Bolivia

Publications

Thiele, G. (1999). “Informal potato seed system in the Andes: Why are they important and what should we do with them?” World Development.51

Thiele, G., A. Devaux, I. Reinos, H. Pico, F. Montesdeoca, M. Pumisacho, J. Andrade-Piedra, C. Velasco, P. Flores, R. Esprella, A. Thomann, M. Manrique and D. Horton (2011). “Multi-stakeholder platforms for linking small farmers to value chains: evidence from the Andes.” International Journal of Agricultural Sustainability 9(3)

Thiele, G., K. Theisen, M. Bonierbale and T. Walker (2010). “Targeting the Poor and Hungry with Potato Science.” Potato Journal 37(3-4): 75-86

Fuglie, K. and G. Thiele (2009). Research Priority Assessment at the International Potato Center (CIP). Prioritizing Agricultural Research for Development. D. A. Raitzer and G. W. Norton, CABI: 25-43

Sarapura-Escobar, Silvia, Hambly-Odame, Helen, and Thiele, Graham. 2015. Gender and Innovation in Peru’s Native Potato Market Chains. Book Chapter. In: Transforming Gender and Food Systems in the Global South. IDRC, Canada (in press). Taylor and Francis

4.2 FLAGSHIP LEADER: FP1 – DISCOVERY RESEARCH FOR ENHANCED UTILIZATION OF RTB GENETIC RESOURCES

Clair H. HERSHEY

Education:

PhD, Cornell University (1978). Major field – Plant Breeding; Minor fields – Entomology; International Agriculture

Professional/Business Skills and Experience

- 2011 – present: Leader, Cassava Program, CIAT, Cali, Colombia
- 2009 – 2010: Visiting Scientist at FAO's Global Partnership Capacity Building Initiative for Plant Breeding (GIPB)
- 2002–2013: Editor, Plant Breeding News (FAO and Cornell University joint sponsorship)
- 1992–Present (active to 2009): Partner, Hershey Brothers Farms (Lancaster County, PA, USA)
- 1992–2009: Consulting in breeding/genetic resources projects and agricultural development,
- 1978-1991: Senior Scientist - Plant Breeder, Cassava Program, International Center for Tropical Agriculture (CIAT), Cali, Colombia
- 1986: Adjunct Associate Professor of Plant Breeding, Dept. of Agronomy, Penn State University (ten-month sabbatical leave from CIAT)
- 1974-1978: Graduate studies and research, Dept. of Plant Breeding and Biometry, Cornell University (Rockefeller Foundation Fellow), including field research in CIMMYT, Mexico

RTB experience

- **2011 to date - *Focal Point–RTB-CIAT:*** Representation of CIAT in RTB; advocating for RTB in CIAT. Preparation of workplans, budgets, reports for CIAT to RTB, member RTB pre-proposal writing team.

Selected Publications

Ceballos, H., Kawuki, R. S., Gracen, V. E., Yencho, G. C., & Hershey, C. H. (2015). Conventional breeding, marker-assisted selection, genomic selection and inbreeding in clonally propagated crops: a case study for cassava. Theoretical and Applied Genetics, 1-21.

Hershey, C.H. and Neate, P. (eds.). (2013). Eco-efficiency: From vision to reality (Issues in Tropical Agriculture series). Centro Internacional de Agricultura Tropical (CIAT), 252 p. -- (CIAT Publication No. 381).

Ceballos, H., Hershey, C., & Becerra-López-Lavalle, L. A. (2012). New approaches to cassava breeding. Plant Breeding Reviews, Volume 36, 427-504.

Mba, C., Guimaraes, E. P., Guei, G. R., Hershey, C., Paganini, M., Pick, B., & Ghosh, K. (2012). Mainstreaming the continuum approach to the management of plant genetic resources for food and agriculture through national strategy. Plant Genetic Resources, 10(01), 24-37.

Guimaraes, E. P., Debouck, D., Beebe, S. E., Pompilio Martínez, C., Hershey, C. H., & Ceballos, H. (2011). Pre-breeding. an alternative to add value to the plant genetic resources. Sveriges Utsädesförenings Tidskrift [Journal of the Swedish Association], 118(2).

4.3 FLAGSHIP LEADER: FP2 – ADAPTED PRODUCTIVE VARIETIES AND QUALITY SEED OF RTB CROPS

Elmar SCHULTE-GELDERMANN

Education

PhD - University Kassel, Witzenhausen. Management approaches in organic potato and tomato production - Interactive impacts of agronomic measures on plant nutrition, plant health and yield.

Master of Science (Dipl. Agraringenieur), University of Kassel, Witzenhausen. Management strategies to control late blight studies in organic agricultural science.

Professional experience

International Potato Center (2012-present): *Program Leader: CIP Strategic Objective 3-Seed Potato for Africa; Potato Science Leader- SSA; Integrated Crop Management Scientist, Program and project leadership*

University of Kassel, Germany – 2004-2009: Research assistant at the department of “Plant Protection”. Researcher in bilaterally funded projects at departments of “Plant Protection” and “Organic Farming and Cropping Systems”

IGW- Fricke & Turk GmbH, Witzenhausen-Institute GmbH, Germany, Organic Resource Agency, Malvern UK and, IGLux s.a r.l., Dudelange Luxemburg – 1993-2004: Freelance consultant in project management at cooperating waste management offices

Association for Technology and Structures in Agriculture (KTBL), Darmstadt, Germany – 2002-2004: Freelance consultant - Evaluation and documentation of time efficiency and costs of pre-germination, harvesting and storage systems in potato production

Major scientific contributions

- Establishment of Aeroponics Technology in Seed Potato Multiplication, Kenya
- Seed System Framework – Case study 3G project
- Tackling the food price crisis in Eastern/Central Africa with the humble potato: Enhanced productivity and uptake through the “3G” revolution
- Wealth Creation Through Potatoes: Increasing Production and Developing New Market Opportunities for Smallholder Potato Growers in Ethiopia, Kenya, Uganda
- Backstopping of private and public sector potato seed multipliers at all levels of multiplication. Research on low cost on-farm seed quality maintenance technologies (Positive Selection and Small Seed Plot Technology, Net tunnel technology to produce healthy sweetpotato etc.)
- Selection and evaluation of potato breeding lines.
- Leading regional projects, related above mentioned topics, implemented in 8 Eastern and Central African countries

Selected publications

Schulte-Geldermann, E.; Gildemacher, P. R.; Struik, P. C. 2012: Improving Seed Health and Seed Performance by Positive Selection in Three Kenyan Potato Varieties. American Journal of Potato Research vol. 89: issue 6. p. 429 – 437 DOI 10.1007/s12230-012-9264-1.

P. R. Gildemacher, E. Schulte-Geldermann, D. Borus, P. Demo, P. Kinyae, P. Mundia and P. C. Struik, 2011: Seed Potato Quality Improvement through Positive Selection by Smallholder Farmers in Kenya Potato Research (2011) 54:253–266, DOI 10.1007/s11540-011-9190-5.

E. Schulte-Geldermann, P.R. Gildemacher and P. Struik 2015: Improving Seed Health and Seed Performanceby Positive Selection in Three Kenyan Potato Varieties. In: Potato and Sweetpotato in Africa: Transforming the Value Chains for Food and Nutrition Security, edited by Jan Low, Moses Nyongesa, Sara Quinn and Monica Parker. CABI, in press, p. 254-260

P. Demo, B. Lemaga, R. Kakuhenzire, S. Schulz, D. Borus, I. Barker, G. Woldegiorgis, M.L. Parker and E. Schulte-Geldermann 2015: Strategies to Improve Poor Seed Potato Quality and Supply in Sub-Saharan Africa: Experience from Interventions in Five Countries In: Potato and Sweetpotato in Africa: Transforming the Value Chains for Food and Nutrition Security, edited by Jan Low, Moses Nyongesa, Sara Quinn and Monica Parker. CABI, in press, p. 155-167

4.4 FLAGSHIP LEADER: FP3 – RESILIENT RTB CROPS

James Peter LEGG

Education

PhD, University of Reading, UK, Whiteflies and geminiviruses, 1992-95.

MSc, University of Reading, UK, Crop Protection, 1988-89.

BA, MA, University of Oxford, UK, Pure and Applied Biology, 1984-88.

Professional Experience

- 2008-2015: Senior Scientist, IITA, Dar es Salaam, Tanzania
- 2000-2008: Senior Scientist, NRI/IITA, Dar es Salaam, Tanzania
- 1998-1999: Associate Scientist, IITA, Kampala, Uganda
- 1995-1997: Post-doctoral Fellow, IITA, Kampala, Uganda

a) RTB experience

June 2013 to date

RTB Theme Leader – Theme 3 (Pests and Diseases) and Lead Writer – RTB FP 3 (Resilient RTB crops) and cluster CA3.7 (cassava biological threats/Africa)

January 2015 to date: ***Focal Point–RTB-IITA:*** Representation of IITA in RTB; advocating for RTB in IITA. Preparation of workplans, budgets, reports for IITA to RTB, member RTB pre-proposal writing team.

b) Recent Professional Experience

2008-2015: *Senior Scientist, IITA. Dar es Salaam, Tanzania*

- Research for development primarily on cassava virus diseases and their vectors; wide range of field, screenhouse and laboratory-based approaches involving studies of virus-vector interactions, virus characterization, epidemiology, molecular ecology, bioinformatics, biological control, IPM, seed systems.
- Leadership of bilateral projects, student supervision and working with a diverse range of governmental, NGO and private sector partners. Most of the work is based in East, Southern and Central Africa, but strong research linkages have been built up over time with a global network of research partners.
- Senior mentoring role currently supervising 1 post-doctoral fellow, 5 PhD and 5 MSc students.

Selected Publications

Legg, J. P., Lava Kumar, P., Makeshkumar, T., Ferguson, M., Kanju, E., Ntawuruhunga, P., Tripathi, L. and Cuellar, W. (2015). Cassava virus diseases: biology, epidemiology and management. Advances in Virus Research. 91, 85-142. DOI: 10.1016/bs.aivir.2014.10.001.

Patil B. L., Legg, J. P., Kanju, E. and Fauquet, C. M. (2015). Cassava brown streak disease: A threat to food security in Africa. Journal of General Virology. DOI: 10.1099/jgv.0.000014.

Legg, J. P., Sseruwagi, P., Boniface, S., Okao-Okuja, G., Shirima, R., Bigirimana, S., Gashaka, G., Herrmann, H. -W., Jeremiah, S. C., Obiero, H. M., Ndyetabula, I., Tata-Hangy, W., Masembe, C. and Brown, J. K. (2014). Spatio-temporal patterns of genetic change amongst populations of cassava Bemisia tabaci whiteflies driving virus pandemics in East and Central Africa. Virus Research 186, 61-75. http://dx.doi.org/10.1016/j.virusres.2013.11.018.

Legg, J. P., Somado, E. A., Barker, I., Beach, L., Ceballos, H., Cuellar, W., Elkhoury, W., Gerling, D., Helsen, J., Hershey, C., Jarvis, A., Kulakow, P., Kumar, L., Lorenzen, J., Lynam, J., McMahon, M., Maruthi, G., Miano, D., Mtunda, K., Ntawuruhunga, P., Okogbenin, E., Pezo, P., Terry, E., Thiele, G., Thresh, M., Wadsworth, J., Walsh, S., Winter, S., Tohme, J., & Fauquet, C. (2014). A global alliance declaring war on cassava viruses in Africa. Food Security 6, 231-248.

Legg, J. P. (2012). Cassava Diseases: Ecology and Control. In Encyclopedia of Pest Management. Taylor and Francis, London, UK. DOI: 10.1081/E-EPM-120041170.

4.5 FLAGSHIP FP4 – NUTRITIOUS RTB FOOD AND ADDED VALUE THROUGH POSTHARVEST INTERVENTION

Flagship team members and candidates for flagship team leader

Busie MAZIYA-DIXON

Profile

Busie Maziya-Dixon currently conducts research on nutritional quality, processing, utilization, and product development and evaluation of maize aimed at providing a diversity of secondary food products for rural and urban poor or high value products for the richer consumers. This can open new opportunities for market sales and also offer the possibility of improving dietary intake. In collaboration with partners and other stakeholders, she also coordinates workshops to create awareness of innovative postharvest technologies to enhance adoption of nutritious and safe food products. She also conducts research on nutritional assessment of children under 5 and women of childbearing age to guide in targeting of agricultural-based interventions thus promoting the agriculture-nutrition-health linkage. Together with national partners, she is involved in devising a mechanism for promoting strong linkages between agriculture and nutrition with a gender perspective in order to reduce food insecurity and malnutrition on a sustainable basis.

Education

PhD (Food Science), Kansas State University, Manhattan, Kansas, USA (1992); Major: Cereal chemistry with a minor in nutrition

MSc (Food Science), Kansas State University, Manhattan, Kansas, USA (1989); Major: Food chemistry with a minor in nutrition

BSc (Home Economics), Kansas State University, Manhattan, Kansas, USA (1986)

Professional experience

- 2012 to present: Leader, CGIAR Research Program on Agriculture for Nutrition and Health
- 1999 to present: Food Scientist/Crop Utilization Scientist, Crop Utilization Laboratory, International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria,
- 1994-1996, Associate Lecturer, Department of Food Technology, University of Ibadan, Nigeria

Selected publications

De Moura, F. F., Moursi, M., Lubowa, A., Ha, B., Boy, E., Oguntona, B. E., Sanusi, R., Maziya-Dixon. B. 2015. Cassava intake and vitamin A status among women and preschool children in Akwa-Ibom, Nigeria. PLoS ONE. 10(6) (e0129436):1 -14.

Busie B. Maziya-Dixon and Alfred G. O. Dixon. 2015. Carotenoids content of yellow-fleshed cassava genotypes grown in four agroecological zones in Nigeria and their Retinol Activity Equivalents (RAE). Journal of Food, Agriculture & Environment Vol.13 (2): 63 - 69.

Abdoulaye, T., Abass, A., Maziya-Dixon, B., Tarawali, G., Okechukwu, R., Rusike, J., Alene, A., Manyong, V. , Ayedun, B. 2014. Awareness and adoption of improved cassava varieties and processing technologies in Nigeria. J. Development and Agricultural Economics 6(2):67-75.

Njukwe, E. , Onadipe, O. O. , Amadou Thierno, D. , Hanna, R. , Kirscht, H. , Maziya-Dixon, B., Araki, S., Mbairanodji, A., Ngue-Bissa, T. 2014. Cassava processing among small-holder farmers in Cameroon: opportunities and challenges. Int. Journal of Agricultural Policy and Research. 2(4):113-124.

Oladunmoye, O., Aworh, O., Maziya-Dixon, B., Erukainure, O., Elemo, G. N. 2014. Chemical and functional properties of cassava starch, durum wheat semolina flour, and their blends. Food Science and Nutrition 2(2):132 – 138.

Simon HECK

Education

Ph.D. Boston University, USA (Social Anthropology)

M.A. Johannes Gutenberg Universität, Mainz, Germany (Anthropology, Geography, Political Science)

Professional Experience

The International Potato Center (CIP)

- Program Leader, Strategic Program on Resilient, Nutritious Sweetpotato (Nov. 2014 – present): 30 research projects in 15 countries in Africa and Asia; $22m+ annual budget
- Project Leader, Scaling-up Sweetpotato through Agriculture and Nutrition (Nov. 2013 – present): 5-year $18m project to reach 1.2m households with OFSP; research on scalability
- Deputy Program Manager, Sweetpotato Program in Africa (Oct. 2012 – Oct. 2013)

The WorldFish Center

- Senior Policy Adviser and Country Manager, Zambia (Nov. 2006 – Sep. 2012)
- Senior Social Scientist (Nov. 2003 – Oct. 2006)

IUCN – The World Conservation Union

- Senior Technical Adviser (July 2001 – Oct. 2003)

Department for International Development (DFID)

Socio-economic Adviser (March 1999 – June 2001

Boston University, Boston, USA

- Research Fellow and Lecturer (Sep. 1994 – March 1999)

Selected publications (related to FP4)

Heck, S. and R. Ackatia-Armah. 2015. Scaling-up integrated agriculture-nutrition-market approaches to promote biofortified crops: the case of orange fleshed sweetpotato in four African countries. Paper accepted for presentation at 2nd International Conference on Global Food Security, Ithaca, NY, USA, 11-14 October 2015.

Longley C, Thilsted SH, Beveridge M, Cole S, Nyirenda DB, Heck S and Hother A-L (2014). The Role of Fish in the First 1,000 Days in Zambia. In Harris, Jody; Haddad, Lawrence and Grütz, Silke Seco (2014) Turning Rapid Growth into Meaningful Growth: Sustaining the Commitment to Nutrition in Zambia, Brighton: IDS. Pp. 27-35.

Heck, S., C. Béné, and R.R. Reyes-Gaskin. 2007. Investing in African fisheries: Building links to the millennium development goals. Fish and Fisheries 8:211-226.

Chair, Agro-Enterprise Learning Alliance for Eastern and Southern Africa (2011 – present)

Thierry TRAN

Education

- Postdoctoral researcher, Food Sciences Division, University of Nottingham, UK (*2003 – 2004)*
- PhD (Food Sciences), University of Nottingham, UK and Kellogg, UK/USAv (*1999 – 2003)*
- MSc (Physics & Chemistry, Food engineering). Ecole Supérieure de Physique et Chimie Industrielles (ESPCI), Paris, France. (*1995 – 1999)*

Professional Experience

2009 – present: **Senior researcher**, Centre de Coopération Internationale en Recherche Agronomique pour le Développement **(CIRAD)**, Montpellier, France

- Integrate technical, economic and environmental indicators to model and optimize postharvest processing unit operations, using multi-objective optimization tools. Case study of cassava processing.
- Apply Life Cycle Assessment (LCA) to agro-industrial food products, using case studies of cassava, coffee and cocoa value chains.
- *Since 201: b*ased at Kasetsart University (Thailand) for Carbon footprint assessment of cassava processing, and re-engineering of cassava processing unit operations with focus on rasping and drying technologies.

2005 – 2009: Researcher, Cassava and Starch Technology Research Unit (CSTRU), BIOTEC - Kasetsart University, Thailand

- Physico-chemical and functional properties of starches from cassava, rice and tropical underutilized roots and tubers.

On-going Projects

- **CRP-RTB Postharvest** (complementary funding): Driving livelihood improvements through demand oriented interventions for competitive production and processing of Roots Tubers and Bananas (RTBs). Leader of the CS1 work package "Optimization of selected small and medium processing systems for cassava", I coordinate the activities of partner teams at CIAT, IITA and CIRAD.
- EuropeAid PDMACIM: Sustainable cassava production in Central Africa and market integration.

Selected publications (related to FP4)

Hansupalak N., Piromkraipak P., Tamthirat P., Manitsorasak A., Sriroth K., Tran T. (2015). Biogas reduces the carbon footprint of cassava starch: A comparative assessment with fuel oil. Journal of Cleaner Production. dx.doi.org/10.1016/j.jclepro.2015.06.138. I.F. 3.844.

Tran T., Da G., Moreno-Santander M.A., Velez-Hernandez G.A., Giraldo-Toro A., Piyachomkwan K., Sriroth K., Dufour D. (2015). A comparison of energy use, water use and carbon footprint of cassava starch production in Thailand, Vietnam and Colombia. Resources, Conservation and Recycling 100, 31-40. I.F. 3.026.

Chapuis A., Precoppe M., Méot J.M., Sriroth K., Tran T. (2015). Modelling and design optimisation of small-scale pneumatic dryers for cassava starch. Drying Technology (under review).

Da G., Dufour D., Giraldo A., Moreno M., Tran T., Velez G., Sanchez T., Le Thanh M., Marouzé C., Maréchal P.A. (2013). Cottage level cassava starch processing systems in Colombia and Vietnam. Food and Bioprocess Technology 6(8), 2213-2222. I.F. 3.703.

Maldonado P., Grosmaire L., Dufour D., Giraldo Toro A., Sanchez T., Calle F., Moreno A.M., Ceballos. H., Delarbre J.L., Tran T. (2013). Combined effect of fermentation, sun-drying and genotype on breadmaking ability of sour cassava starch. Carbohydrate Polymers 98, 1137-1146. I.F. 3.942

4.6 FLAGSHIP LEADER: FP5 – INTEGRATED SYSTEMS FOR IMPROVED LIVELIHOODS

Piet J.A. VAN ASTEN

Profile

Piet van Asten is a systems agronomist at IITA-Uganda working on sustainable intensification of perennial-based cropping systems (banana, cassava, cocoa, coffee) in Africa's humid zones for the past 12 years. Over the past years he has been increasingly involved in managing and supporting research for development projects on a regional scale. In his role as IITA-Uganda country representative, he has been able to help attract and manage R4D projects with a total value exceeding 15 million USD between 2013-2015. In his research, he has a strong focus on trans-disciplinary science ranging from the soil pit to household economics, linkages to input-output markets, drivers of technology adoption and policy engagement. He published over 50 publications in peer-reviewed journals and books and has successfully supervised over 30 MSc and PhD students. He has proven experience with linking research to development through participatory research and backstopping of out-scaling partners. His main interests are the development of more productive, profitable, and resilient agricultural systems that enable improved livelihoods of smallholder farmers, including improved opportunities for youth and women.

Education

- 1990-1996: BSc, MSc in Agriculture and Natural Environment, Wageningen University
- 2002-2003: PhD in Soil Science – Agronomy, Wageningen University, Holland.

Professional experience

2003 – present:	Systems agronomist at IITA. Naguru, Uganda
	Managing a.o. the IITA-led R4D activities in CIALCA (since 2006)
	IITA coordinator of CCAFS climate change research (Jan 2011-June 2015)
2002 – 2003:	Research fellow at the Wageningen University (WUR), The Netherlands
1998 – 2002:	Associate scientists at the Africa Rice Center (WARDA), Senegal
1997 – 1998:	Project coordinator on urban agriculture, University of the Western Cape (UWC), RSA
1995 – 1996:	Soil and water management advisor at Agromisa, Wageningen,

Selected publications

Douxchamps, S., M.T. van Wijk, S. Silvestri, A.S. Moussa, C. Quiros, N.Y.B. Ndour, S Buah, L. Somé, M. Herrero, P. Kristjanson, M. Ouedraogo, P.K. Thornton, P. van Asten, R. Zougmoré, M.Rufino, 2015. Linking agricultural adaptation strategies, food security and vulnerability: evidence from West Africa. Regional Environmental Chnge, In press.

Bongers L. Fleskens, G., G. Van de Ven, D. Mukasa, K. Giller, P. van Asten, 2015. Diversity in smallholder farms growing coffee and their use of recommended coffee management practices in Uganda. Experimental Agriculture 1-21.

Campbell, B. M. P., Thornton, R. Zougmoré, P. van Asten, L. Lipper, 2014. Sustainable intensification: What is its role in climate smart agriculture? Current Opinion in Environmental Sustainability 8:39–43.

Vanlauwe, B., D. Coyne, J. Gockowski, S. Hauser, J. Huising, C. Masso, G. Nziguheba, M. Schut, P. Van Asten, 2014. Sustainable intensification and the African smallholder farmer. Current Opinion in Environmental Sustainability 8:15–22

Klapwijk, CJ , MT van Wijk, TS Rosenstock, PJA van Asten, PK Thornton, KE Giller, 2014. Analysis of trade-offs in agricultural systems: current status and way forward, Current Opinion in Environmental Sustainability 6:110–115.

Jassogne, L., P.J.A. van Asten, I. Wanyama, P. Baret, 2012. Perceptions and outlook on intercropping coffee with banana as an opportunity for smallholder coffee farmers in Uganda. *International Journal of Agricultural sustainability* 1-15.

4.7 FLAGSHIP LEADER: FP6 - IMPACT AT SCALE

Elisabetta GOTOR

Profile

Elisabetta is an agricultural economist with more than ten years of professional experience in international research-for-development work in the area of economic analysis and evaluation of agricultural development problems and policies. Since January 2007, she has been working at Bioversity International first as Associate Scientist (2007-2011) and then as a Scientist, leading and managing the Impact Assessment Unit (2011 to date), soon to be merged into the Development Impact Unit. Throughout her professional career she has been keen to develop personal and management skills such as problem solving, dedication, flexibility and willingness to perform a variety of tasks. She has been conducting and leading field work in Bolivia, China, Ecuador, Kazakhstan, Kenya, India, Peru, The Philippines, Uzbekistan and Yemen.

Education

- 2008: PhD, Doctor of Philosophy, (Agricultural and Food Economics; University of Reading, Department of Agricultural and Food Economics, Reading - UK
- 2004: MSc, Master of Science, (International Trade); University of Roma Tre, Department of Economics, Rome- Italy
- 2002: Laurea, Advanced University Degree, Master Equivalent (International Economics); University of Roma Tre, Faculty of Political Science, Rome - Italy

Professional experience

- 2007-To date: Bioversity International (formerly International Plant Genetic Resources Institute, IPGRI), Office of the Deputy Director General-Research, Rome, Italy. **Associate Scientist** (2007-2011) Scientist-Ad Interim Head, Impact Assessment Unit (2011-2015)
- 2005- 2006 University of Reading, Department of Agricultural and Food Economics, Reading-UK

Teaching and Research Assistant

- 2003-2005: Food and Agriculture Organization of the UN (FAO), Raw Material, Tropical and Horticultural Products Service, Rome-Italy. **Consultant** (2004-2005) Volunteer (2003)
- 2002- 2003 University of Roma Tre, Department of Economics, Rome-Italy. **Research Assistant**
- 2001- 2001 Parliamentarians for Global Actions-NGO, New York- USA. **Internship**

Selected publications

Bellon M. R., Gotor E., Caracciolo F. 2015. Assessing the effectiveness of projects supporting on-farm conservation of native crops: evidence from the High Andes of South America. World Development. doi:10.1016/j.worlddev.2015.01.014

Bellon M.R., Gotor E., Caracciolo F. 2015. Conserving landraces and improving livelihoods: how to assess the success of on-farm conservation projects? International Journal of Agricultural Sustainability 13:2 (167-182). doi: 10.1080/14735903.2014.986363

Gotor E. ,Caracciolo , F., Blundo Canto, G.M., and Al Nusairi, M., 2013. Improving rural livelihoods through the conservation and use of underutilized species: evidence from a community research project in Yemen, International Journal of Agricultural Sustainability, DOI:10.1080/14735903.2013.796173

Gotor E., Tsigas M.E., 2011. The impact of the EU sugar trade reform on poor households in developing countries: A general equilibrium analysis: Journal of Policy Modeling, 33:568-582.

Gotor E., Caracciolo F., Watts J., 2010.The Perceived Impact of the In-Trust Agreements on CGIAR Germplasm Availability: An Assessment of Bioversity International’s Institutional Activities. World Development 38 (10): 1486–1493

ANNEX 5: OVERVIEW AND FULL TITLES OF RTB FLAGSHIP PROJECTS AND CLUSTERS OF ACTIVITIES

Annex 5.1 Overview, coding and short titles of FP and clusters

<table>
<tr><td rowspan="2">Flagship Projects:</td><td>DISCOVERY</td><td colspan="4">DELIVERY</td></tr>
<tr><td>FP1:
<u>Enhanced genetic resources</u></td><td>FP2:
<u>Productive varieties & quality seed</u></td><td>FP3:
<u>Resilient crops</u></td><td>FP4:
<u>Nutritious food & added value</u></td><td>FP5:
<u>Integrated livelihood systems</u></td></tr>
<tr><td rowspan="2">Clusters of Activity:</td><td>DI1.1 (Breeding platform)
DI1.2 (Next generation breeding)
DI1.3 (Game changing traits)
DI1.4 (In-situ conservation)
DI1.5 (Adding value to genebanks)</td><td>CC2.1 (Quality seeds & access to improved varieties)
BA2.2 (User preferred banana cultivars/hybrids)
CA2.3 (Added value cassava varieties)
PO2.4 (Potato quality seed)
PO2.5 (Potato varieties for Asia)
SW2.6 (User preferred sweetpotato varieties)
YA2.7 (Quality seed yam)</td><td>CC3.1 (Pest/disease management)
CC3.2 (Crop production systems)
BA3.3 (Banana fungal diseases/Foc)
BA3.4 (Banana viral diseases/BBTV)
BA3.5 (Banana bacterial diseases/BXW)
CA3.6 (Cassava biological constraints, Asia/Americas)
CA3.7 (Cassava biological threats, Africa)</td><td>CC4.1 (Postharvest innovation & nutrition improvement)
CA4.2 (Cassava processing)
CA4.3 (Biofortified cassava)
SW4.4 (Nutritious sweetpotato)</td><td>CC5.1 (Sustainable intensification/diversification)
CC5.2 (Institutional innovations)
PB5.3 (East and Central Africa)
PB5.4 (West Africa)
PB5.5 (Central Mekong)
PB5.6 (Tropical Americas and Caribbean)</td></tr>
<tr><td colspan="5">FP 6: <u>Impact at scale</u>
CC6.1 (Knowledge, capacities, partnerships)
CC6.2 (Strategic gender research)
CC6.3 (Foresight, impact assessment)</td></tr>
</table>

Note: prefix indicates crop where relevant: DI=discovery, CC=cross cutting, BA=banana, CA=cassava, PO=potato, SW=sweetpotato, YA=yam, PB=place based.

Annex 5.2 Full titles of FPs and clusters

FP 1: Discovery research for enhanced utilization of RTB genetic resources
DI1.1: RTB Breeding Platform **DI1.2**: Next Generation Breeding for Roots, Tubers and Bananas **DI1.3**: Genetically engineered RTB varieties with game-changing traits **DI1.4**: Sustaining the evolution of RTB agrobiodiversity and benefits to custodian farmers through a Global network of RTB in-situ conservation **DI1.5**: Adding value to genebanks
FP 2: Adapted productive varieties and quality seed of RTB crops
CC2.1: Improving smallholder access to healthy RTB planting material and new varieties **BA2.2:** Matching banana cultivars and hybrids with farmers', consumers' and markets' needs, for more sustainable food and production systems **CA2.3:** Added value cassava varieties for high impact markets and end users **PO2.4:** Improving Livelihoods of Potato Farmers in Africa by Tackling Deteriorated Seed Quality through an Integrated Approach **PO2.5:** Agile potato for Asia **SW2.6:** User preferred sweetpotato varieties and seed technologies **YA2.7:** Yam varieties and sustainable seed systems
FP 3: Resilient RTB crops
CC3.1: Management of RTB-critical pests and diseases under changing climates, through risk assessment, surveillance, enhanced modeling, and advanced IPM **CC3.2**: Sustainable RTB Crop Production Systems **BA3.3**: Management strategies to reduce losses caused by Fusarium wilt and enhance productivity in banana **BA3.4**: Improving the livelihoods of smallholder banana producers in Asia and Africa through recovery and containment of banana bunchy top disease **BA3.5**: Regional framework for full recovery of banana production systems affected by BXW in East and Central Africa **CA3.6**: Preemptive, emergency, and ongoing response capacity to manage emergent biological constraints for cassava in Asia and the Americas **CA3.7**: Responses to biological threats to cassava in Africa
FP 4: Nutritious RTB food and added value through postharvest intervention
CC4.1: Demand-led approaches to drive postharvest innovation and nutrition improvements **CA4.2:** Raising incomes and improving the health and safety at small and medium cassava processing centers, preferentially for women and youth in rural and urban areas **CA4.3:** Biofortified cassava varieties for improved nutrition and livelihoods **SW4.4**: Nutritious sweetpotato in expanding markets and improved diets
FP 5: Integrated systems for improved livelihoods
CC5.1: Sustainable intensification and diversification (SID) **CC5.2:** Institutional innovations, decision-support and youth employment **PB5.3:** East and Central Africa **PB5.4:** West Africa lowlands **PB5.5:** Central Mekong **PB5.6:** Tropical Americas and Caribbean
FP 6: Impact at scale
CC6.1 Knowledge, capacity and partnerships for scaling **CC6.2** Strategic research and support for gender transformation **CC6.3** Foresight and impact assessment

ANNEX 6: RTB COLLABORATIONS MATRIX WITH GLOBAL INTEGRATING AND AFS CRPS

Annex 6.1 RTB collaboration matrix with Global Integrating CRPs

CRP	Activity	RTB Role (and flagship)	Collaborating CRP Role	Value Addition	Countries
POLICIES, INSTITUTIONS AND MARKETS (PIM)	Foresight	Contribute with crop models (FP6)	• Leadership by PIM; cost sharing Use the International Model for Policy Analysis of Agricultural Commodities and Trade (IMPACT) model to generate mid- and long-term projections of supply and demand of RTB crops	Improved alignment of RTB investment with market opportunities	Global
	Ex-ante assessment	Run ex-ante impact assessment models for promising RTB technologies based on rates of return (FP6)	Use the IMPACT model to enhance ex-ante impact assessment of RTB technologies in a holistic model, including multiple commodities (Future Harvest+)	More robust ex-ante assessment, with information on indicators of economic welfare and food security in more continuous manner	Global
	Scaling innovations	Application of typology to improve scaling strategies in FP2-FP5 (FP6)	• Complementary analysis and development of a typology of scaling models and tools, investment schemes and a framework for assessing the outcomes of scaling • Knowledge sharing and scaling through value chain hubs, across commodities, CRPs and partners	Framework for learning across multiple value chains and improving scaling strategy	Global
	Value chain tools, methods and assessments	• Share lessons with others through PIM value chains platform • Action learning on tool development in specific contexts to strengthen the design, implementation and assessment of interventions aimed at inclusive and efficient value chains • Develop the concept of coaching in gender and value chains (FP2, FP4, FP5)	• Coordinates development of tools • Provide tools and methods for value chain development and scaling and guide their development • Include gender in "Participatory Market Chain analysis" 5Capitals and other value chain methods	• Improved tools and methods and accelerated learning. • Synergies across multiple value chains, connect research to key policy decisions and deliver large development outcomes as measured against the SRF framework	Around the emerging Value Chain hubs in South America and West and East Africa

CRP	Activity	RTB Role (and flagship)	Collaborating CRP Role	Value Addition	Countries
	Post-harvest losses framework	Apply framework to evaluate losses and improve postharvest management (FP4)	Develop framework to evaluate the extent and sources of postharvest losses/methodology to measure postharvest losses along different stages of the value chain that can be replicated across regions and crops/ differentiating losses in terms of quantity, quality and value	Consistent method for measuring postharvest losses and guiding research investment to area of highest pay-off	Uganda and Peru
	Gender analysis	Apply, adapt and improve guidelines for sex disaggregation of data in baseline and other surveys (FP6)	Developing guidelines for collecting sex-disaggregated data and integrate feedback from RTB	Improved uniformity and quality of sex-disaggregated data across CRPs	Global
	Geospatial mapping	Geospatial mapping with RTBMaps (FP6)	Collaboration through the CGIAR-wide geospatial working group for common ontology and interoperability of databases	Cost saving and access to big data	Global
AG RICULTURE FOR NUTRITION AND HEALTH (A4NH) & POLICIES INSTITUTIONs AND MARKETS (PIM)	Breeding/germplasm development	• Leads overall breeding program of biofortified crops • Supports and uses high- throughput diagnostics for vitamin levels and other quality traits (FP2)	Leads high-throughput diagnostics (NIRS platform) for vitamin levels and other quality traits (minerals, sugars, dry matter, etc.)	Ensure that nutritional traits embedded in varieties with good agronomic and consumer-preferred traits	Global
	Nutritional efficacy and bioavailability studies	User of information in breeding programs (FP2)	Primary responsibility for studies	Ensure nutritional efficacy in released varieties	Global
	Delivery in target value chains and Evidence/ Advocacy	Leads on key agriculture value chain delivery and contributes to cost effectiveness studies (FP2, FP4)	Leads on the nutrition evidence and public delivery related to improving nutrition and health in target populations	Advocacy for nutrition friendly value chains	Global
	Value chain coordination, food processing, food industry, and assessing nutrition and health outcomes	• Leads facilitation with key value chains, with a particular focus on gender relations as RTB commercialization increases • Joint work on processing and foods (FP2, FP4)	• Study incentives and arrangements as they relate to consumption and improving nutritional quality (including gender), standards for biofortified products, and food safety • Joint work on processing and	Broad based coalition for improving nutrition responsive value chain coordination	Global

CRP	Activity	RTB Role (and flagship)	Collaborating CRP Role	Value Addition	Countries
			foods. • Policies affecting value chains, economics of value chain transformation (e.g., scaling up to supermarkets, etc.) (with PIM)		
	Assessing RTB value chains for nutrition and health	Shares in implementation of assessment methods, contributing a crop-specific and place based perspective (FP2, FP4, FP5)	• Contribute with tools and methods for assessments of nutritional quality, food safety, and health benefits • Contribute with tools and methods for value chain assessment (with PIM)	Program evaluation capacity of A4NH helps RTB learn from the implementation and scaling processes to strengthen impact	Global
	Projections & trends in technology impacts, production, consumption, utilization of RTB crops	Provides information on RTB crops and parameters of most promising technologies; brings RTB perspectives and demands in different regions (FP2, FP4, FP5, FP6)	Contribute with tools, methods, and analysis to assess impact and major drivers of trends; provides baselines and scenarios (with PIM)	Trends and projections rooted in deep understanding of RTB production systems at regional levels	Global
CCAFS	Climate-Smart Breeding	Utilize foresight, metrics and models to improve selection and definition of traits (FP1,FP2)	Develop Foresight, metrics and models for climate-smart breeding with (CCAFS F1);	Co-invest to develop climate sensitive breeding strategies, especially trait prioritization (CCAFS models & metrics);	Global
	Climate modelling to forecast future impacts on biotic and abiotic factors affecting RTB crop production	Incorporate effects of climate change in insect crop life cycle modelling, and disease models (eg Blightcast); (FP2, FP3)	Joint research on modelling climate change effects on pests and diseases and on adaptation in the applied Climate Smart Village approaches	Improved understanding of climate change impacts on pests and diseases and success of control measures	East Africa
	Climate-Smart farming	Incorporation of climate change in research on resilience in cropping systems across climate gradients (FP2, FP3, FP5)	• Shared intervention sites, technology transfer, shared farm system diagnostics and needs assessments; shared M&EL systems; • Improving the resilience of maize-based farming systems through RTB diversification	• Mutual technology validation from a systems and/or resilience research perspective. • Co-location of scientists; Joint investments in tools development, partnering, and scaling.	Climate Smart Villages, Vietnam, SSA

CRP	Activity	RTB Role (and flagship)	Collaborating CRP Role	Value Addition	Countries
	Foresight on climate change	Includes climate change in ex ante impact assessment (FP6)	Modelling, horizon scanning and foresight analysis, policy analysis	Enhanced foresight considering climate change in RTB	
WLE	Landscape restoration	Use framework and tools in cassava-based degraded soils, SE Asia (FP3, FP5)	Framework, tools and approaches for landscape restoration	Integration of agronomic practices into landscape context	South East Asia Vietnam, Thailand
	Waste and water management	Adapt and validate technology for waste and water management with small scale processors (FP4)	Ecosystem level approaches for managing processing waste and water (with Livestock)	More efficient processing and utilization of waste from small scale cassava processing	Nigeria
GENEBANKS	Value enhancement of germplasm collections	Greater efficiency in use of genetic resources collections through facilitated use of accession-based traits for selection of germplasm (FP1, FP2)	Partnering with the genebanks for accession-based association of traits of interest for RTB	Reduced time and resources and greater availability for in use and incorporation of traits of interest from germplasm collections into improved varieties	Global
	Mining biodiversity for trait discovery	Unique, novel and variant forms of important traits are uncovered from germplasm collections (FP1- FP4)	Collaborative research to identify accessions and traits with novel traits important for achieving RTB goals.	Identification of genes/genetic regions that can encode traits of value that can be incorporated into elite varieties	Global
	Pre-breeding	Genebanks will collaborate with RTB to source, evaluate and propagate wild or non-adapted sources for germplasm enhancement and pre-breeding. (FP1)	Combined activities to integrate gene/traits of interest into germplasm that can be readily adopted and used in breeding programs.	Making genes/traits available for breeding programs which would otherwise be too time consuming or difficult to use	Global
	Database & information management	Develop accession-specific trait associations readily searchable in a public database (FP1 - FP4)	Shared breeding and genebank databases through a public portal in such a way that accession can be selected by phenotype or genotype	Silico selection of genebank accessions greatly increasing the efficiency of the selection of genebank materials for breeding programs	Global

Annex 6.2 RTB collaboration matrix with AFS CRPs

	Activity	RTB Role (and flagship)	Collaborating CRP Role	Value Addition	Countries
INTER AFS COLLABORATION	Shared genotyping, high-throughput phenotyping, and bioinformatics platforms	User and contributor to shared platforms (FP1, FP2)	Expand Genomic and Open-source Breeding Informatics Initiative (GOBII) Continue to promote use of shared platforms: eg Integrated Breeding Platform and CGIAR Big Data Platform	Increased critical mass and use of big data	Global
	Germplasm improvement	Hub for clonally propagated crops (FP1, FP2)	Shared phenotyping platforms	Reduction in cost of service provision	Global
	Sustainable intensification incl systems research, e.g. livelihoods	• Use multi crop frameworks to guide research around eg residue use in a whole farm context and multipurpose SP as food, feed and cover crop to reduce soil erosion • Modeling diversified farming systems. Joint analysis of crop integration. Joint design of land and soil management (FP5)	Shared frameworks and approaches for full (multi) purpose crops: eg improving fodder resources from crop residues	Improved integration of innovation processes in multi crop context, and assessments of resilience through scenario simulation	Global
	Genetics linked Cap Dev	Utilize as basis for CapDev, coordination with Breeding Platform (FP1, FP2)	BECA as genetics-related training hub for all AFS-CRPs for	Improved critical mass, reduction in costs	Global
	M&EL	Member of community of practice user of shared/interoperable M&EL platform (FP6)	• Joint M&EL framework, methods and tools (e.g. e-household), interoperability of platforms (ongoing preparations 2014-16), ideally common platform • Platform: Metrics for breeding cycle, e.g. how to monitor progress on	Faster, more precise, genetic gain, more structured variety and trait pipelines	Global
	Targeting & prioritizing	Active participant, link to RTB maps (FP6)	Renew GIS Community of Practice	Shared framework for analysis/ setting priorities	Global
FISH	Multifunctional landscapes	Integrating RTB crops into aquatic production systems (FP5)	Multifunctional landscapes, with more resilient and ecologically sustainable RTB and aquatic production systems	Improved resilience of RTB production systems	Bangladesh, Cambodia, Zambia, ,
	Ecosystem services and improved nutrition	Incorporate aquatic production as dimension of trade-offs analysis in livelihoods (FP5)	Ecosystem service trade-offs and synergies (e.g. nutrition) due to expansion of RTB or aquatic production systems	Improved alignment of research with full range of livelihood options	Zambia, Bangladesh

	Activity	RTB Role (and flagship)	Collaborating CRP Role	Value Addition	Countries
	Foresight work	Shared work on foresight linked to site integration (FP6)	Methods and tools for foresight work in relation to climate change and other drivers of change	Foresight work considers whole livelihood context	Bangladesh
LIVE-STOCK	Improving use of RTB crops for feed	Selection of sweetpotato varieties suited to feed and validation of options for utilizing waste in RTB crop production and processing for feed (FP4, FP5)	Developing optimal feed technologies and animal production systems adapted to specific RTB crops and waste products	Expanded utilization of RTB crops and their residues for feed	Uganda, Nigeria
FTA	Reducing impacts on forests and optimizing production in agro-forestry system	• Research on intensifying RTB to reduce environmental impact • Research on banana cultivars and their management linked to specific agro-forestry systems (FP3, FP5)	Framework for managing RTB systems to minimize impacts on forest environments Optimizing management of banana production in agro-forestry systems	Sustainable intensification of RTB systems	West Africa
	Livelihood analysis	Incorporate tree crops in livelihood analysis (FP5)	Livelihood systems analysis on mixed tree-crop and RTB crops	Better targeting of research	Global
DCLAS	Rotation and inter-crop/ companion crops.	• Adapt potato varieties and their management as rotation crop with grain legumes and dryland cereals • Sweetpotato varieties for intercropping and for enhancing the quality of cereal residues as animal feed (FP2, FP4, FP5)	• Grain legumes and dryland cereals varieties and agronomic practices adapted to intercropping • Guide selection of best RTB crops and varieties for rotation	Exchange tools/methods for systems analysis	Asia
MAIZE	Rotation and inter-crop/ companion crops.	• Adapt RTB varieties and their management as rotation crop or inter crop with maize • Sweetpotato varieties for intercropping and for enhancing the quality of cereal residues as animal feed (FP2 and FP5)	• Maize varieties and agronomic practices adapted to intercropping or rotation with RTB crops • Guide selection of best RTB crops and varieties for rotation	Strengthen resilience of maize-based systems with RTB crops	Africa, LAC
RAFS	Rotation crops/companion crops.	Adapt RTB varieties and their management as rotation and inter crop with rice (FP2, FP3, FP5)	• Integration potato in rice based systems • Guide selection of best RTB crops and varieties for rotation	Integrated approach to resilient cropping	India, Bangladesh, China; West & East Africa (inland valley systems)
WHEAT	Rotation crops/companion crops	Adapt potato varieties and their management as rotation crop with wheat (FP2, FP5)	• Wheat varieties and agronomic practices adapted to intercropping • Guide selection of best RTB crops and varieties for rotation	Integration potato in wheat based systems	Asia

ANNEX 7: REFERENCES

PART 1: SUMMARY NARRATIVE

CGIAR. 2015, Final Results for identifying countries for Site Integration+ and Site Integration++. Based on results of survey for Steps 1, 2 and 3. Version: 23/07/2015 (unpublished)

Christensen, 2000, Innovator's Dilemma: When New Technologies Cause Great Firms to Fail (Management of Innovation and Change) Harvard Business Review Press

Davey, M.W., I. Van den Bergh, R. Markham, R. Swennen, and J. Keulemans. 2009. Genetic variability in Musa fruit provitamin A carotenoids, lutein and mineral micronutrient contents. Food Chemistry 115(3): 806–813.

FAO. 2014. The State of Food and Agriculture: Innovation in family farming. FAO, Rome

FAOStat Production. Accessed on July 13, 2015. http://faostat3.fao.org/download/Q/QC/E

Horton, D., G. Prain, and G. Thiele. (2010). Perspectives on Partnership: Highlights of a Literature Review. ILAC Brief 25.

IEA (Independent Evaluation Arrangement), 2014. Review of CGIAR Research Programs Governance and Management. IEA, 2014 Governance evaluation

ISPC, SPIA 2014. Adoption of modern varieties of food crops in Sub-Saharan Africa. Impact Brief No. 42.

Margolis, A., and E., Buckingham (2013). The Importance of Gender in Linking Agriculture to Sustained Nutritional Outcomes. Agriculture and Nutrition Global Learning and Evidence Exchange (AgN-GLEE), Joint USAID & SPRING conference, Guatemala City, Guatemala from March 5-7, 2013.

Mudege, N.N.; Chevo, T.; Nyekanyeka, T.; Kapalsa, E.; Demo, P. 2015. Gender norms and access to extension services and training among potato farmers in Dedza and Ntcheu in Malawi.Journal Article The Journal of Agricultural Education and Extension. (UK). ISSN 1389-224X. Published online 13 May 2015. 16 p. http://dx.doi.org/10.1080/1389224X.2015.1038282.

Robinson, J. and C.S. Srinivasan. (2013). Case-Studies on the Impact of Germplasm Collection, Conservation, Characterization and Evaluation (GCCCE) in the CGIAR. CGIAR Standing Panel on Impact Assessment. - See more at: http://ciatblogs.cgiar.org/support/spotlight-on-ciats-cassava-research-in-asia/#sthash.tUemKW5p.dpuf

RTB. 2013. CGIAR Research Program on Roots, Tubers and Bananas- RTB Gender Strategy

Sarapura, S. 2012. Gender Analysis for the Assessment of Innovation Processes: The Case of Papa Andina in Peru. In: The World Bank. Agricultural Innovation Systems: An investment sourcebook. Washington, D.C., USA. pp. 598-602.

Thiele, G., K. Theisen, Bonierbale, M. and Walker, T. (2010). "Targeting the Poor and Hungry with Potato Science." Potato Journal 37(3-4): 75-86.

Woolley, J. Johnson, V. Ospina, B. Kemaga, B. Jordan, T. Harrison, G. Thiele G. (2011) incorporating stakeholder perspectives in international agricultural research; the case of the CGIAR Research Program for Roots, Tubers and Bananas for Food Security and Income. International Potato Center (CIP), Lima Peru. Social Science Working Pater 2011-3.

World Bank: World development report 2015: mind, society, and behavior. World development report. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/2014/11/20458440/world-development-report-2015-mind-society-behavior

RTB Priority Assessment

Abdoulaye, T., Alene, A., Rusike, J. and Adebayo, A. 2014. Results of a global online expert survey: Major constraints, opportunities, and trends for yam production and marketing and priorities for future RTB yam research. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-4. Available online at: https://goo.gl/Ji2Vdw

Abdoulaye, T., Alene, A., Rusike, J. and Adebayo, A. 2014. Strategic Assessment of Yam Research Priorities. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-3. Available online at: https://goo.gl/Ji2Vdw

Alene, A., Oleke, J., Rusike, J., Abdoulaye, T., Creamer, B, Del Río, M. and Rodriguez, J. 2014. Strategic Assessment of Cassava Research Priorities. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-5. Available online at: https://goo.gl/Ji2Vdw

Creamer, B, Rusike, J., Gonzalez, C., Rodriguez, J.J., Abdoulaye, T. and Alene, A. 2014. Prioritization of options for Cassava research for development – Results from a global expert survey. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-6. Available online at: https://goo.gl/Ji2Vdw

Hareau, G., Kleinwechter, U., Pradel, W., Suarez, V., Okello, J. and Vikraman, S. 2014. Strategic Assessment of Research Priorities for Potato. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-8. Available online at: https://goo.gl/Ji2Vdw

Hareau, G., Kleinwechter, U., Pradel, W., Suarez, V., Okello, J. and Vikraman, S. 2014. Strategic Assessment of Research Priorities for Sweetpotato. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-9. Available online at: https://goo.gl/Ji2Vdw

Kleinwechter, U., Hareau, G. and Suarez, V. 2014. Prioritization of options for sweetpotato research for development – Results from a global expert survey. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-10. Available online at: https://goo.gl/Ji2Vdw

Kleinwechter, U., Hareau, G., Suarez, V. 2014. Prioritization of options for potato research for development - Results from a global expert survey. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-7. Available online at: https://goo.gl/Ji2Vdw

Pemsl, D.E. and Staver, C. 2014. Strategic Assessment of Banana Research Priorities. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-1. Available online at: https://goo.gl/Ji2Vdw

Pemsl, D.E., Staver, C., Creamer, B., Abdoulaye, T., Alene, A. and Rusike, J. 2014. Results of a global online expert survey: Major constraints, opportunities and trends for banana production and marketing and priorities for future RTB banana research. Lima (Peru). CGIAR Research Program on Roots, Tubers and Bananas (RTB). RTB Working Paper 2014-2. Available online at: https://goo.gl/Ji2Vdw

PART 2: FLAGSHIP LEVEL

FLAGSHIP PROJECT 1: DISCOVERY RESEARCH FOR ENHANCED UTILIZATION OF RTB GENETIC RESOURCES

Castañeda-Álvarez, N.P., de Haan, S., Juárez, H., Khoury, C.K., Achicanoy, H.A., Sosa, C.C., Bernau, V., Salas, A., Heider, B., Simon, R., Maxted, N., Spooner, D. 2015. *Ex situ* conservation priorities for the wild relatives of potato (*Solanum* L. section *Petota*). PLOS ONE. DOI: 10.1371/journal.pone.0122599 potat

Cenci, A.; Guignon, V.; Roux, N.; Rouard, M. 2014. Genomic analysis of NAC transcription factors in banana (Musa acuminata) and definition of NAC orthologous groups for monocots and dicots. Plant Molecular Biology 85(1-2): 63-80. ISSN: 0167-4412 http://dx.doi.org/10.1007/s11103-013-0169-2

De Haan, S., Polreich, S., Rodriguez, F., Juarez, H., Plasencia, F., Ccanto, R., Alvarez, C., Otondo, A., Sainz, H., Venegas, C. and J. Kalazich. 2014. A long-term systematic monitoring framework for on-farm conserved potato landrace diversity. Investigación e innovación para la seguridad y soberanía alimentaria en Bolivia in: Revista Científica de Investigación Info-INIAF. Milan, M., Otondo, A., Vicente, J.J., Cabrera, C. and J. Campero (eds.). No. 4, Vol. 1, 31-40.

Folgado, R., Panis, B., Sergeant, K., Renaut, J., Swennen, R., and Hausman, J.F. 2013. Differential protein expression in response to abiotic stress in two potato species: Solanum commersonii Dun and Solanum tuberosum L. International Journal of Molecular Sciences, 14, 4912-4933. http://www.mdpi.com/1422-0067/14/3/4912.

Folgado, R., Sergeant, K., Renaut, J., Swennen, D., Hausman, J.F., and Panis, B. 2014. Changes in sugar content and proteome of potato in response to cold and dehydration stress and their implications for cryopreservation. Journal of Proteomics, 98, 99-111. http://dx.doi.org/10.1016/j.jprot.2013.11.027.

Gaj, T, CA Gersbach and CF Barbas. 2013. ZFN, TALEN, and CRISPR/Cas-based methods for genome engineering. Trends in biotechnology, 31(7), 397-405.

Khoury C.K., Heider B., Castañeda-Álvarez N.P., Achicanoy H.A., Sosa C.C., Miller R.E., Scotland R.W., Wood J.R.I., Rossel G., Eserman L.A., Jarret R.L., Yencho G.C., Bernau V., Juarez H., Sotelo S., de Haan S. and Struik P.C. 2015. Distributions, ex situ conservation priorities, and genetic resource potential of crop wild relatives of sweetpotato [Ipomoea batatas (L.) Lam., I. series Batatas]. Frontiers Plant in Science 6:251. doi: 10.3389/fpls.2015.00251

Kyndt, T., Quispe, D., Zhai, H., Jarret, R., Ghislain, M., Liu, Q., Gheysen, G., Kreuze, J.F., 2015. The genome of cultivated sweet potato contains Agrobacterium T-DNAs with expressed genes: An example of a naturally transgenic food crop. Proc Natl Acad Sci U S A 112, 5844–5849. doi:10.1073/pnas.1419685112

Lindqvist-Kreuze, H., Manuel Gastelo, Willmer Perez, Gregory A. Forbes, David de Koeyer, and Merideth Bonierbale (2014) Phenotypic Stability and Genome-Wide Association Study of Late Blight Resistance in Potato Genotypes Adapted to the Tropical Highlands. Phytopathology June 2014, Volume 104, Number 6. Pages 624-633.http://dx.doi.org/10.1094/PHYTO-10-13-0270-R

Nyaboga, E., Tripathi, J., Manoharan, R., Tripathi, L. (2014) Agrobacterium-mediated genetic transformation of yam (Dioscorea rotundata): An important tool for functional study of genes and crop improvement. Frontiers in Plant Science, 5(463): 1-14, ISSN 1664-462X. http://dx.doi.org/ 10.3389/fpls.2014.00463

Pérez-de-Castro, A.m., S. Vilanova, J. Cañizares, L. Pascual, J.M. Blanca, M.J. Díez,J. Prohens,* and B. Picó. 2012. Application of Genomic Tools in Plant Breeding. Curr Genomics. 2012 May; 13(3): 179–195.

Rabbi IY, Hamblin M, Gedil M (2014a) Genetic Mapping Using Genotyping-by-Sequencing in the Clonally Propagated Cassava. Crop Sci. 1–13. doi: 10.2135/cropsci2013.07.0482

Rabbi IY, Hamblin MT, Kumar PL, et al. (2014b) High-resolution mapping of resistance to cassava mosaic geminiviruses in cassava using genotyping-by-sequencing and its implications for breeding. Virus Res 186:87–96. doi: 10.1016/j.virusres.2013.12.028

RTB, 2015. RBM Pilot Report: Next Generation Breeding for Roots, Tubers and Bananas (NextGen Breeding).

Särkinen, T.; Baden, M.; Gonzáles, P.; Cueva, M.; Giacomin, L.; Spooner, D.M.; Simon, R.; Juárez, H.; Nina, P.; Molina, J. and Sandra Knapp. 2015. Annotated checklist of Solanum L. (Solanaceae) for Peru. Revista peruana de biología 22(1): 003 – 062.doi: http://dx.doi.org/10.15381/rpb.v22i1.11121

Tessema, G., Hyma, K. E., Asiedu, R., Mitchell, S. E., Gedil, M., Spillane, C. (2014). Next-generation sequencing based genotyping, cytometry and phenotyping for understanding diversity and evolution of guinea yams. Theoretical and Applied Genetics, 127(8): 1783-1794, ISSN 0040-5752. http://dx.doi.org/ 10.1007/s00122-014-2339-2

Vanhove, A.-C., Vermaelen, W., Swennen, R., and Carpentier, S. 2015. A look behind the screens: Characterization of the HSP70 family during osmotic stress in a non-model crop. Journal of Proteomics, 119, 10-20. http://www.sciencedirect.com/science/article/pii/S1874391915000238.

FLAGSHIP PROJECT 2: ADAPTED PRODUCTIVE VARIETIES AND QUALITY SEED OF RTB CROPS

Ahmed, J. 2015 Potato Seed Impact study report: Interim study report on the impact of adopting certified potato seed in Meru County (2011-2014). International Potato Center. Nairobi, Kenya.

Ceballos, Hernán, Robert S. Kawuki, Vernon E. Gracen, G. Craig Yencho and Clair H. Hershey. 2015. Conventional breeding, marker-assisted selection, genomic selection and inbreeding in clonally propagated crops: a case study for cassava. Theor Appl Genet DOI 10.1007/s00122-015-2555-4Christinck Anja (ed.), Weltzien Eva (ed.), Hoffmann Volker (ed.). 2005. Setting breeding objectives and developing seed systems with farmers: A handbook for practical use in participatory plant breeding projects. Weikersheim: Margraf Publishers, pp. 123-152. ISBN 3-8236-1449-5

Davey, M.W., Garming, H., Ekesa, B.N., Roux, N. and Van den Bergh, I. 2009. Exploiting banana biodiversity to reduce vitamin A deficiency related illness: a fast and cost-effective strategy. p.1-16. In: Stanley, R., Dietzgen, R. and Gidley, M. (eds.). Proceedings of the tropical fruits in human nutrition and health conference 2008. DEEDI, Brisbane (AUS). http://era.deedi.qld.gov.au/1553/

Demo, P., B. Lemaga, R. Kakuhenzire, S. Schulz, D. Borus, I. Barker, G. Woldegiorgis, M.L. Parker and E. Schulte-Geldermann 2015: Strategies to Improve Poor Seed Potato Quality and Supply in Sub-Saharan Africa: Experience from Interventions in Five Countries. In: Potato and Sweetpotato in Africa: Transforming the Value Chains for Food and Nutrition Security, edited by Jan Low, Moses Nyongesa, Sara Quinn and Monica Parker. CABI, in press, p. 155-167

Ly, D., Hamblin, M., Rabbi, I., Melaku, G., Bakare, M., Gauch, H. G., Okechukwu, R., Dixon, A.G.O., Kulakow, P., & Jannink, J. L. (2013). Relatedness and Genotype× Environment Interaction Affect Prediction Accuracies in Genomic Selection: A Study in Cassava. Crop Science, 53(4), 1312-1325.

Mudege, Netsayi N., Tafadzwa Chevo, Ted Nyekanyeka, Eliya Kapalasa & Paul Demo (2015): Gender Norms and Access to Extension Services and Training among Potato Farmers in Dedza and Ntcheu in Malawi, The Journal of Agricultural Education and Extension, DOI: 10.1080/1389224X.2015.1038282

Ortiz, R. and Swennen, R. 2014. From crossbreeding to biotechnology-facilitated improvement of banana and plantain. Biotechnology Advances 32(1):158-169. http://dx.doi.org/10.1016/j.biotechadv.2013.09.010

Rabbi, Ismail; Hamblin, Martha; Gedil, Melaku; Kulakow, Peter; Ferguson, Morag; Ikpan, Andrew S.; Ly, Delphine; Jannink, Jean-Luc. 2014. Genetic Mapping Using Genotyping-by-Sequencing in the Clonally Propagated Cassava. Crop Science, 54(4): 1384-1396. DOI: 10.2135/cropsci2013.07.0482

Tecle, I. Y., J. Edwards, N. Menda, C. Egesi, I. Y. Rabbi, P. Kulakow, R. Kawuki, J-L Jannink, L. A. Mueller. 2014. solGS: a web-based tool for genomic selection. BMC Bioinformatics 15(1):398.

Thomas-Sharma, S., A. Abdurahman, S. Ali, J. L. Andrade-Piedra, S. Bao, A. O. Charkowski, D. Crook, M. Kadian, P. Kromann, P. C. Struik, L. Torrance, K. A. Garrett and G. A. Forbes. 2015. Seed degeneration in potato: the need for an integrated seed health strategy to mitigate the problem in developing countries. Plant Pathology, accepted online, DOI: 10.1111/ppa.1243.

Tushemereirwe, W., Batte, M., Nyine, M., Tumuhimbise, R., Barekye, A., Tendo, S., Talengera, D., Kubiriba, J., Lorenzen, J., Swennen, R. and Uwimana, B. 2015. Performance of NARITA banana hybrids in the preliminary yield trial for three cycles in Uganda. IITA, NARO, Uganda. 35p.

FLAGSHIP PROJECT 3: RESILIENT RTB CROPS

Alvarez, E., Pardo, J.M., Mejía, J.F., Bertaccini A., Thanh, H.D, and Hoat, T.X. (2013). Detection and Identification of a 16SrI Group Phytoplasma associated with Witches Broom Disease of Cassava in Vietnam. *Phytopathogenic Mollicutes* 3(2): 77-81

Blomme, G., Jacobsen, K., Ocimati, W., Beed, F., Ntamwira, J., Sivirihauma, C., Ssekiwoko, F., Nakato, V., Kubiriba, J., Tripathi, L., Tinzaara, W., Mbolela, F., Lutete, L., and Karamura, E. (2014). Fine-tuning banana Xanthomonas wilt control options over the past decade in East and Central Africa. *European Journal of Plant Pathology*, 1–17. http://doi.org/10.1007/s10658-014-0402-0

FAO. 2008. Climate-related transboundary pests and diseases. http://www.fao.org/3/a-ai785e.pdf

Hodgetts J, Karamura G, Johnson G, Hall J, Perkins K, Beed F, Nakato V, Grant M, Studholme DJ, Boonham N and Smith J (2014). Development of a lateral flow device for in-field detection and evaluation of PCR based diagnostic methods for *Xanthomonas campestris* pathovar *musacearum*, the causal agent of Banana Xanthomonas Wilt. *Plant Pathology*, DOI:10.1111/ppa.12289

Köberl, M., Dita, M., Martinuz, A., Staver, C., & Berg, G. (2015). Agroforestry leads to shifts within the gammaproteobacterial microbiome of banana plants cultivated in Central America. *Frontiers in Microbiology*, 6(February), 1–10. http://doi.org/10.3389/fmicb.2015.00091

Kroschel, J., M. Sporleder, H.E.Z. Tonnang, H. Juarez, P. Carhuapoma, J.C. Gonzales and R. Simon (2013). Predicting climate change caused changes in global temperature on potato tuber moth Phthorimaea operculella (Zeller) distribution and abundance using phenology modeling and GIS mapping. *Journal of Agricultural and Forest Meteorology* 170, 228-241.

Kroschel, J., N. Mujica, J. Alcazar, V. Canedo & O. Zegarra (2012): Developing integrated pest management for potato: Experiences and lessons from two distinct potato production systems of Peru. In: Sustainable Potato Production: Global Case Studies (Zhongqi He, R.P. Larkin, C.W. Honeycutt, Eds.). Springer. UK, 419-450.

Kumar, P. L., Selvarajan, R., Iskra-Caruana, M.-L., Chabannes, M., & Hanna, R. (2015). Control of Plant Virus Diseases - Vegetatively-Propagated Crops. *Advances in Virus Research* 91. Elsevier. http://doi.org/10.1016/bs.aivir.2014.10.006

Legg, J.P., Lava Kumar, P., Makeshkumar, T., Ferguson, M., Kanju, E., Ntawuruhunga, P., Tripathi, L. and Cuellar, W. 2015. Cassava virus diseases: biology, epidemiology and management. *Advances in Virus Research* 91, 85-142. DOI: 10.1016/bs.aivir.2014.10.001

Mollot G, Duyck P-F, Lefeuvre P, Lescourret F, Martin J-F, Piry S, et al. (2014) Cover Cropping Alters the Diet of Arthropods in a Banana Plantation: A Meta-barcoding Approach. *PLoS ONE* 9(4): e93740. doi:10.1371/journal.pone.0093740

Norton, G.W., E.A. Heinrichs, G.C. Luther, and M.E. Irwin, 2005. Globalizing integrated pest management: a participatory research process. Hoboken, NJ: Wiley-Blackwell.

Parsa, S., Hazzi, N. a., Chen, Q., Lu, F., Herrera Campo, B. V., Yaninek, J. S., & Vásquez-Ordóñez, A. A. (2014). Potential geographic distribution of two invasive cassava green mites. *Experimental and Applied Acarology*, 65(2), 195–204. http://doi.org/10.1007/s10493-014-9868-x

Parsa, S., Kondo, T., & Winotai, A. (2012). The Cassava Mealybug (*Phenacoccus manihoti*) in Asia: First Records, Potential Distribution, and an Identification Key. *PLoS ONE*, 7(10). http://doi.org/10.1371/journal.pone.0047675

Patil, B. L., Legg, J. P., Kanju, E., & Fauquet, C. M. (2015). Cassava brown streak disease: a threat to food security in Africa. *Journal of General Virology*, 96, 956–968. http://doi.org/10.1099/vir.0.000014

Smith, J. (2015). Crops, crop pests and climate change – why Africa needs to be better prepared. CCAFS Working Paper no. 114. Copenhagen, Denmark. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). https://ccafs.cgiar.org/publications/crops-crop-pests-and-climate-change-%E2%80%93-why-africa-needs-be-better-prepared-0#.VZJRamNtlIQ

Tripathi L, Mwangi M, Abele S, Aritua V, Tushemereirwe WT and Bandyopadhyay R. (2009). Xanthomonas wilt: A threat to banana production in East and Central Africa. *Plant Disease* 93, 440-451.

Tripathi, L., Tripathi, J. N., Kiggundu, A., Korie, S., Shotkoski, F., & Tushemereirwe, W. K. (2014). Field trial of Xanthomonas wilt disease-resistant bananas in East Africa. *Nature Biotechnology*, 32(9), 868–870. http://doi.org/10.1038/nbt.3007

Zeddies J, Schaab RP, Neuenschwander P and Herren HR. (2001). Economics of biological control of cassava mealybug in Africa. *Agricultural Economics* 24, 209-219.

FLAGSHIP PROJECT 4: NUTRITIOUS FOOD AND VALUE ADDED THROUGH POST HARVEST INNOVATION

Chapuis A., Precoppe M., Meot J.M., Sriroth K., Tran T. (2015). Model-based optimisation of a flash conveying dryer for cassava starch. Journal of Food Engineering (submitted).

Devaux, A., D. Horton, Velasco, C., Thiele, G., Lopez, G., Bernet, T., Reinoso, I., Ordinola, M. (2009). "Collective Action for Market Chain Innovation in the Andes." Food Policy **34** 31-38.

FAO, IFAD and WFP. 2015. *The State of Food Insecurity in the World 2015.Meeting the 2015 international hunger targets: taking stock of uneven progress.*Rome, FAO.

Hansupalak, N., P. Palotai, Tamthirat, P., Manitsorasak, A., Sriroth, K., y Tran, T. 2015. Biogas reduces the carbon footprint of cassava starch: a comparative assessment with fuel oil. Journal of Cleaner Production (http://dx.doi.org/10.1016/j.jclepro.2015.06.138).

Herforth, A. Lidder, P. and Gill, M. 2015. Strengthening the links between nutrition and health outcomes and agricultural research. Food Sec. 7:457–461 DOI 10.1007/s12571-015-0451-z

Hotz, C. et al. 2012. A large-scale intervention to introduce orange sweet potato in rural Mozambique increases vitamin A intakes among children and women. *British Journal of Nutrition*, 108, 163–176 doi:10.1017/S0007114511005174

IPCC, 2014: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, 1132 pp.

Okike, Iheaanacho, Samireddypalle Anandan, Kaptoge, Lawrence, Fauque Claude, Atehnkeng Joseph, Bandyopadhyay Ranajit, Kulakow Peter, Duncan Alan, Alabi Tunrayo, Blummel Alabi: 2015 Technical innovations for small-scale producers and households to process wet cassava peels into high quality animal feed ingredients and aflasafe™ substrate Food Chain Vol 5 1-2 pp 71-90

International Food Policy Research Institute (IFPRI). 2014. *Global Nutrition Report 2014: Actions and Accountability to Accelerate the World's Progress on Nutrition*. Washington, DC.

The *Economist*, Special Report: Nigeria, "After oil," June 20, 2015.

Tran T., Da G., Moreno-Santander M.A., Velez-Hernandez G.A., Giraldo-Toro A., Piyachomkwan K., Sriroth K., Dufour D. (2015). Distribution of energy use, water use and carbon footprint in cassava starch production: A unit operation level analysis. *Resources, Conservation and Recycling* 100, 31-40.

UNEP Environment for Development, chapter 1 (overview) 2007: http://www.unep.org/geo/geo4/report/01_Environment_for_Development.pdf

FLAGSHIP PROJECT 5: INTEGRATED SYSTEMS FOR IMPROVED LIVELIHOODS

Doss, C.R. 2001. Designing Agricultural technology for African Women Farmers: Lessons from 25 years of experience. *World Development* 29(12): 2075-2092

Geels, F.W. 2004. From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. *Research Policy* 33: 897–920.

Giller, K.E. 2013. Can we define the term 'farming systems'? A question of scale. Guest Editorial. Outlook on *Agriculture* 42(3): 149-153.

Hounkonnou, D., Kuyper, T., Kossou, D., Leeuwis, S., Nederlof, C., Röling, N., Sakyi-Dawson, O., Traoré, M., and van Huis. A. 2012. An Innovation Systems Approach to Institutional Change: Smallholder Development in West Africa. *Agricultural Systems* 108: 74-83.

Leeuwis, C., Schut, M., Waters-Bayer, A., Mur, R., Atta-Krah, K., and Douthwaite, B. 2014. Capacity to innovate from a system CGIAR research program perspective. Penang, Malaysia: CGIAR Research Program on Aquatic Agricultural Systems. *Program Brief*: AAS-2014-29.

Ojiem, J.O., et al. 2006. "Socio-ecological niche: a conceptual framework for integration of legumes in smallholder farming systems." *International Journal of Agricultural Sustainability* 4.1: 79-93.

Röling, N. 2009. Pathways for impact: scientists' different perspectives on agricultural innovation. IJAS 7(2): 83-94.

Vanlauwe, B., Coyne, D., Gockowski, J., Hauser, S., Huising, J., Masso, C., Nziguheba, G., and Van Asten, P. 2014. Sustainable intensification and the smallholder African farmer. *Current Opinion in Environmental Sustainability* 8: 15-22.

FLAGSHIP PROJECT 6: IMPACT AT SCALE

Abidin, P.E., Dery, E., Kweku Amagloh, F., Asare, K., and Crey, E.E. 2015. Training of Trainers' Module for Orange-Fleshed Sweetpotato (OFSP): Utilization and Processing. International Potato Center (CIP), Lima, Peru.

AfranaaKwapong, N., and Nkonya, E. 2015. Agricultural Extension Reforms and Development in Uganda. Journal of Agricultural Extension and Rural Development 7 (4): 122-134.

Alene, A.D., Abdoulaye, T., Rusike, J., Manyong, V., and Walker, T. 2015. "The Effectiveness of Crop Improvement Programs from the Perspectives of Varietal Output and Adoption: Cassava, Cowpea, Soybean, and Yam in Sub-Saharan Africa and Maize in West and Central Africa". In: Walker, T.S. and Alwang, J.R. (editors), 2015. Crop Improvement, Adoption, and Impact of Improved Varieties in Food Crops in Sub-Saharan Africa (forthcoming CABI book).Cawsey, T.F., Deszca, G., and Ingols, C. 2015. Organizational Change: An Action-Oriented Toolkit. Sage Publications, Thousand Oaks, CA, USA.

Cernea, M., and Kassam, A.H. (eds.). 2006. Researching the Culture in Agriculture: Social Research for International Development. CABI Publishing. CABI, Wallingford, Oxfordshire, UK.

CGIAR Capacity Development Community of Practice 2015. Capacity Development Framework. Prepared by CGIAR Capacity Development Community of Practice for the second round of CGIAR Research Programs. Version date: X June 2015

Crane, T.A. 2014. Bringing Science and Technology Studies into Agricultural Anthropology: Technology Development as Cultural Encounter between Farmers and Researchers. Culture, Agriculture, Food and Environment 36 (1): 45-55.

Ekboir, J.M., Canto, G.B. and Sette, C. 2013. Monitoring the composition and evolution of the research networks of the CGIAR Research Program on Roots, Tubers and Bananas. Series on Monitoring Research Networks No. 01. Rome, Italy: Institutional Learning and Change Initiative.

Foran, T., Butler, J.R.A., Williams, L.J., Wanjura, W.J., Hall, A., Carter, L., and Carberry, P.S. 2014. Taking Complexity in Food Systems Seriously: An Interdisciplinary Analysis. World Development 61: 85-101.

Fuglie, K., and G. Thiele. 2009. Research Priority Assessment at the International Potato Center (CIP). Prioritizing Agricultural Research for Development. D. A. Raitzer and G. W. Norton, CABI: 25-43.

Hall, A. 2012. Partnerships in Agricultural Innovation: Who Puts Them Together and Are They Enough? In: OECD (ed.) Improving Agricultural Knowledge and Innovation Systems: OECD Conference Proceedings. OECD Publishing, pp. 219-235.

Horton, D., Prain, G., and Thiele, G. 2009. Perspective on Partnership: A Literature Review. Working Paper 2009-3. CIP, Lima, Peru.

Kajikawa, Y., Tacoa, F., and Yamaguchi, K. 2014. Sustainability Science: The Changing Landscape of Sustainability Research. Sustainability Science 9 (4): 431-438.

Labarta, R. 2015. The Effectiveness of Potato and Sweetpotato Improvement Programs from the Perspectives of Varietal Output and Adoption in Sub---Saharan Africa. In: Walker, T.S. and Alwang, J.R. (editors), 2015. Crop Improvement, Adoption, and Impact of Improved Varieties in Food Crops in Sub-Saharan Africa (forthcoming CABI book).

Lundy, M., Gottret, M.V., and Best, R. 2012. Linking Research and Development Actors through Learning Alliances. In: World Bank (ed.) Agricultural Innovation Systems: A Sourcebook. World Bank, Washington, DC, USA, pp. 344-349.

Mudege, N.N.; Chevo, T.; Nyekanyeka, T.; Kapalsa, E.; Demo, P. 2015. Gender norms and access to extension services and training among potato farmers in Dedza and Ntcheu in Malawi.Journal Article The Journal of Agricultural Education and Extension. (UK). ISSN 1389-224X. Published online 13 May 2015. 16 p. http://dx.doi.org/10.1080/1389224X.2015.1038282

Prain, G., Thiele, G., Ortiz, O., and Campilan, D. 2006. Rootcrops in Agricultural Societies: What Social Research has Revealed. In: Cernea, M. and Amir H Kassam (eds). Researching the Culture in Agri-Culture: Social Research for International Development. CABI, Wallingford, Oxfordshire, UK.

Qureshi, M.E., Dixon, J., and Wood, M. 2015. Public Policies for Improving Food and Nutrition Security at Different Scales. Food Security 7 (2): 393-403.

Sarapura Escobar, S., and Puskur, R. 2015. Gender Capacity Development and Organizational Culture Change in the CGIAR Research Program on Aquatic Agricultural Systems: A Conceptual Framework. WorldFish, Penang, Malaysia.

Schut, M., van Paassen, A., Leeuwis, C., and Klerkx, L. 2014. Towards Dynamic Research Configurations: A Framework for Reflection on the Contribution of Research to Policy and Innovation Processes. Science and Public Policy 41 (2): 207-218.

Thiele, G., van de Fliert, E., and Campilan, D. 2001. What happened to participatory research at the International Potato Center? Agriculture and Human Values 18: 429-446.

Wheatley, C., Prain, G., and Campilan, D. 2015. Research-Development Partnerships for Going to Scale: RTB Experience with IFAD on Asian Food Security, 2011-2014. SHINES Working Paper 3. CIP, Lima, Peru (forthcoming)

GENDER NARRATIVE

CGIAR. 2013. Assessment of the status of Gender Mainstreaming in CGIAR research programs. CGIAR Consortium, prepared by Ashby, J., Lubbock, A., and Stuart, H.

FAO. 2011. The State of Food and Agriculture 2010–2011. Women in Agriculture. Closing the gender gap for development. FAO, Rome.

Fischer, W., and Qaim, M. 2012. Linking Smallholders to Markets: Determinants and Impacts of Farmer Collective Action in Kenya. *World Development* 40(6): 1255–1268.

Mudege, N.N.; Chevo, T.; Nyekanyeka, T.; Kapalsa, E.; Demo, P. 2015. Gender norms and access to extension services and training among potato farmers in Dedza and Ntcheu in Malawi.Journal Article The Journal of Agricultural

Education and Extension. (UK). ISSN 1389-224X. Published online 13 May 2015. 16 p. http://dx.doi.org/10.1080/1389224X.2015.1038282

RTB. 2013a CGIAR Research Program on Roots Tubers and Bananas—RTB Gender Strategy http://www.rtb.cgiar.org/gender-publications/

RTB. 2013b. Gender Capacity Strengthening Plan for the CGIAR Research Program on Roots Tubers and Bananas

RTB. 2013c. A Synthesis Report on Gender Research Undertaken by RTB Centers 2007–2012. Synthesized by Eva Rathgeber and N. N. Mudege, with input from gender focal points.

World Bank, FAO, and IFAD. 2009. Gender in agriculture source book. Agriculture and Rural Development.

www.rtb.cgiar.org

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CIAT — Centro Internacional de Agricultura Tropical / International Center for Tropical Agriculture — Consultative Group on International Agricultural Research

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